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For as long as I can remember, intercepts between Russia and NORAD assets from the USAF and RCAF have taken place off the coast of Alaska. From grainy black-and-white images that first appeared in publications in the 1970s through to the friendly intercepts in 1989, with Russian MiG-29 Fulcrums being intercepted and escorted by USAF F-15s part-way to the Abbotsford Air Show in Canada, how things have changed.

With much of the world's attention focusing on military operations in Ukraine and Israel, Iran has now openly heightened tensions by launching 180 ballistic missiles in retaliation for Israeli strikes against what it calls its 'axis of resistance' allies. Thousands of miles

away in the cold skies of the Arctic, Russian aircraft are reported to have been escalating their confrontational behaviour and continue to push the limits of what is internationally acceptable in terms of an air intercepts within the NORAD Alaska Air Defense Identification Zone (ADIZ).

China has also now regularly appeared near the ADIZ, following instructions from China's General Secretary, Xi Jinping, to adopt a power-projection capability in the air and at sea across the globe. A key focus area of this new policy is the Arctic, which is rich in untapped natural resources. The area will prove critical in the years ahead, with East and West seeking to establish their land claims and secure new trade routes as the global climate changes.

Western nations, particularly the US,

must deploy their military forces across multiple global fronts as a potential contingency force and a deterrent. The need to support and ensure that enough current frontline equipment is operational and effective is biting hard into the US defence budget, impacting some significant programmes, none more so than NGAD.

As numerous defence analysts have pointed out, the West has basically driven the Chinese, the Russians, the North Koreans and the Iranians closer together. All four have a deep-seated interest in countering the US and its allies. It's now a case of what this will cost the West.



Glenn Sands
Editor

TOP:

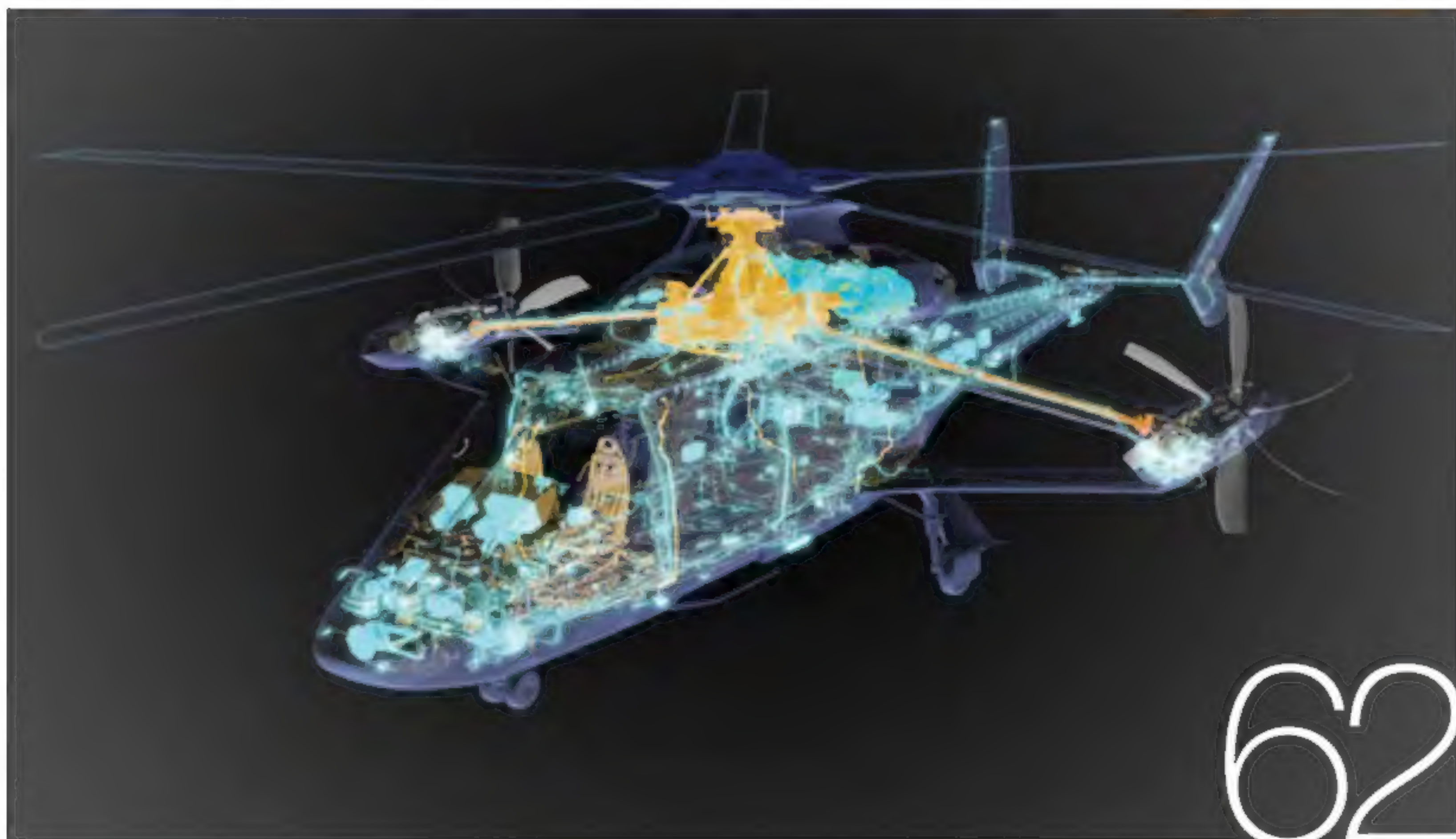
An indication of escalating tensions in the Arctic region was witnessed on September 23, when USAF F-16s conducted an intercept on a Tu-95 in the Alaska ADIZ. The conduct of one Russian Su-35 was deemed "unsafe, unprofessional and not what you'd see from a professional air force," according to a USAF statement by NORAD Commander General Gregory Guillot

NORAD

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The new EA-37B Compass Call electronic warfare aircraft, developed by L3Harris Technologies will replace the USAF's elderly EC-130H fleet

L3Harris Technologies



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Strike

Severe disruption to Boeing airliner

More than 33,000 IAM machinists walked out in mid-September 2024
Boeing

Turbulent' seems an understatement when describing the recent few years for Boeing. There was the 737 MAX's lengthy grounding after two major disasters, followed by critical reports by the US Congress and Senate. Then there were multiple delays to the 777X and a mid-air blow-out of a door plug in a new 73, leading to quality control and manufacturing concerns. This led to investigations into safety culture, accusations about the treatment of whistleblowers, Federal Aviation Administration scrutiny of manufacturing processes, mounting losses and the Starliner spacecraft returning to Earth empty, with two astronauts spending months on the International Space Station. Now industrial action is seriously

disrupting airliner production.

More than 33,000 machinists from the International Association of Machinists and Aerospace Workers (IAM) Union District 751 – some 94.6% of all Boeing workers – went on strike on September 13, 2024, in the first walk-out of IAM members at Boeing for 16 years. The staff had rejected a new contract offer from Boeing offering a 25% pay rise over four years, complaining about stagnant wages and raising concerns over healthcare and pensions, the last related to a defined contribution retirement plan introduced a decade ago.

In a last-ditch effort to reach a deal before the strike, Boeing president and CEO Kelly Ortberg said: "A strike would put our shared recovery in jeopardy, further eroding trust with our customers and hurting our ability to determine our future together." However, 96% of IAM members voted to strike.

IAM International President Brian Bryant said on September 13, 2024: "Boeing must stop undervaluing its workforce. Our members deserve a contract that reflects their hard work and sacrifices. This fight is about more than just a contract. It's about ensuring all our members feel Boeing appreciates their sacrifice over the past decade."

Although 787 production continues at the non-unionised North Charleston factory in South Carolina, the IAM walkout meant the Renton and Everett factories stopped producing the 737 – the cash-cow for Boeing Commercial Airplanes – and the 777 and 767.

When the strike began, one analyst told the *Associated Press* that the stoppage could cost Boeing around \$3bn. Yet the strike remains unresolved and subsequent talks between IAM and Boeing broke down. On October 4, 2024, each side



action!

production after machinists walk out in Seattle

seemed firmly entrenched as the strike entered its fourth week. IAM District 751 said in a post on X: "As of today, there are no scheduled negotiations with the company. We are always ready and willing to continue bargaining through direct or mediated talks."

The IAM 751 X account posted a quote from IAM 751 President Jon Holden: "I believe [Boeing] is hoping that the economic pressure of not having a paycheck or having our health care run out is going to make our members' confidence waver. And it's not."

The UK's *Financial Times* reported that the strike was leaving a "shuddering" supply chain for the 737, 767 and 777. It also said that supplier Spirit AeroSystems was planning to begin furloughing employees from mid-October. According to the *FT*, Boeing's chief financial officer and executive VP, Brian West, told the

supply chain in September that Boeing was "planning to make significant reductions in supplier expenditures... specifically for the non-787 programmes. If you're not behind, and we have safety stock, don't deliver any more."

Airlines voiced concern about the impact of the strike on aircraft deliveries, which are already strained by long-term supply chain issues. In announcing monthly traffic statistics on October 4, 2024, Geir Karlsen, CEO of Norwegian, said: "The strike will delay our deliveries well into next summer and increase short-term costs, requiring us to prioritise cost-saving measures. We are considering various mitigating actions to overcome the shortage of aircraft, such as lease renewals."

Various financial/business media reports in late September 2024 said credit rating agencies Fitch, Moody and S&P would strongly consider downgrading

Boeing's credit rating if the strike continued. All three agencies had Boeing at the lowest rung of investment grade in mid-September, meaning any downgrade would lower it into speculative-grade or 'junk' territory. Bloomberg reported in early October 2024 that Brian West had said that Boeing would "prioritise the investment grade credit rating." It claimed Boeing is considering raising at least \$10bn in equity by selling new stock to shore up the company's cash position.

Boeing's third-quarter results presentation was scheduled for October 23, 2024. The latest quarterly call was always going to be notable because it would be the first to involve the new Boeing president and CEO, Kelly Ortberg, since he took over the role on August 8, 2024. The strike makes the announcement even more keenly anticipated. **Mark Broadbent AI**



Preparing for tomorrow, today

In contrast to current Department of Defense programmes, particularly those associated with the USAF, Northrop Grumman's B-21 Raider appears to be bucking previous trends that have seen severe delays coupled with escalating programme costs. A recent update from Northrop Grumman on the progress that it is making with the B-21 Raider highlighted several key areas where the OEM and the USAF are pleased with the progress of the current flight test campaign.

Northrop Grumman's programme management approach is centred on producing and adopting digital technology to deliver an effective and critically affordable system to the USAF that can be adapted to emerging future threats.

The B-21 Raider is flying from Edwards Air Force Base, home to the Combined Test Force (CTF). The Raider's CTF comprises personnel from Northrop Grumman and the USAF who are responsible for evaluating the Raider's full range of capabilities, from basic handling and functionality of its mission systems to

software integration and more.

Initial feedback from Northrop's test pilots has confirmed the first test vehicle is performing well in flight and flying like the simulators used for training.

"Overall, I am pleased to see the performance of our test jet. The handling qualities are better than expected coming out of the simulated environment – validating the accuracy of the digital models the team has developed and analysed over many years," said Chris 'Hoss' Moss, B-21 Raider test pilot, Northrop Grumman. Flight testing continues to expand the operational envelope, and model predictions are matching flight test data, demonstrating the value and efficacy Northrop Grumman's digital ecosystem is delivering on B-21.

"Flight test is an exciting time, and we're making great progress on B-21," said Tom Jones, corporate vice president and president of Northrop Grumman Aeronautics Systems. "The CTF team has demonstrated we can execute multiple flight test events within the span of a week. Northrop Grumman's digital ecosystem

is enabling that progress, allowing us to analyse test data, make updates and return to flight test with speed and efficiency."

Ground test performance is a critical stage of the Raider's development. Northrop Grumman has successfully verified the B-21 structural design by completing static testing, validating original models and signifying a solid structural design. The OEM has also begun fatigue testing on another ground test article to simulate a lifetime of flight conditions on the aircraft structure.

"The progress we've made on B-21 in the last 12 months is remarkable. The consistent alignment of our digital models on the ground and in flight gives us additional confidence as we look ahead to delivering on B-21," Jones stated in a recent company press release.

Northrop Grumman has taken the strategic approach of building the first test aircraft in the B-21 series using the same methods that will be used on the production Raiders. This is a shift away from the familiar process of taking



a demonstration-like vehicle-to-flight test, which may differ in areas from the production aircraft in many cases. It means that the workforce involved in the B-21 programme is already familiar with production tooling and the materials, and may well have proposed innovative ways of manufacturing repeatable techniques before full aircraft production, allowing an optimal build process to be established by Northrop Grumman once underway, which has included advanced manufacturing and introducing digital tooling into the production line.

Jones added: "We are expanding the use of augmented reality tools and advanced robotics to drive efficiency and accuracy with repeatable, precision processes.

"Northrop Grumman is finding innovative ways to introduce advanced technologies in a restricted manufacturing environment today while paving the way for sustainment processes at the depot

and flight line of the future over the B-21 programme life cycle."

An example of such techniques is Northrop Grumman's manufacturing technicians' use of augmented reality headsets to install various subsystem components into the Raider, alongside robotic tools for adding layers of specialised coatings applied to the outer sections of the B-21.

The recent update on the B-21 Raider programme was supported by the USAF releasing film footage of the aircraft departing and returning to Edwards following another test flight. A statement from Gen Thomas Bussiere, USAF Global Strike Commander, supported the update: "Nobody on the planet can do what we're doing right now. Nobody on the planet can build an exquisite, technologically advanced platform like the B-21. And quite frankly, nobody on the planet can hold at risk what we can hold at risk as a

time and place of our choosing."

Ground test performance is another essential piece of aircraft development. Northrop Grumman successfully verified the B-21 structural design with the completion of static testing, thus validating original models and signifying a solid structural design. The company has also begun fatigue testing on another ground test article to simulate a lifetime of flight conditions on the aircraft structure.

"The progress we've made on B-21 in the last 12 months is remarkable. The consistent alignment of our digital models both on the ground and in flight gives us additional confidence as we look ahead to delivering on B-21," Jones said.

With rapid progress being made with the B-21 Raider, the USAF has already started preparing Ellsworth AFB, South Dakota, to be the first operating base for the B-21. The USAF intends to have up to 100 B-21 Raiders in service. **AI**



MAIN IMAGE:
Performance data aligns with digital predictions as the B-21 Raider flight test programme progresses. The USAF has three B-21 bombers in test –one flying and two focussed on ground-testing. The programme is aiming for two test flights per week
 Northrop Grumman

LEFT:
In 2021, a B-21 Raider Environmental Protection Shelter (EPS) prototype was constructed at Ellsworth Air Force Base, South Dakota. The base was selected as the test site for the EPS because it provides the most extreme and diverse weather conditions for testing the temporary structures
 Airman First Class Quentin Marx/USAF

All bright and beautiful at Teesside



Airborne Colours, Europe's only privately-owned aircraft painting company, unveiled its new £6.5m facility at Teesside International Airport on October 1. The company also unveiled the first aircraft to have been painted there: a Jet2 Boeing 737-800. Steve Darbyshire, founder and chief executive of Airborne Colours, said: "It's an absolute honour and of great pride for me to play a key part in what is to be the newest, most advanced paint facility to be built at Teesside Airport. This really is a dream come true to be able to return to my roots and bring employment back to the area where I grew up."

The launch follows the completion of the 27,000sq ft paint facility – the first built in the UK this millennium. S&A Fabrications was the main contractor on the development, which took less than a year to build.

This unveiling is planned to be the first of several initiatives taking place Teesside International according to MD Phil Forster, who told *Air International*: "This is a small regional airport, but the drive I have for the site is that it's been purchased for economic regeneration. What I mean by that is jobs, inward investment and inbound tourism. It's fair to say the airport had been left to rack and ruin, with little investment and ambition. When I came here and the new shareholders came on board around six years ago, we looked at things differently."

"We still want to be able to fly to leisure destinations, but for a regional airport, that's not enough. We have Ryanair, Tui and KLM – they all fly the usual routes. But we have been looking at how we can diversify at the

ABOVE LEFT:
Airborne Colours plans to repaint around 35 aircraft each year at their new facility at Teesside International Airport
All images via Teesside International Airport

ABOVE RIGHT:
Steve Darbyshire, founder and chief executive of Airborne Colours, with Phil Forster, managing director of Teesside International Airport (right), celebrate the opening of the new paint facility

airport and already have the ingredients in place. We have surface access, infrastructure and development. We have a population of 2.5m within a 90-minute drive, who are all potential passengers or business opportunities from locations down in Yorkshire through to the northeast. Teesside can provide the coverage."

Forster points out that Teesside International is already looking into the air cargo world, in part due to the impressive rail and seaport links available to the airport. Beyond this, Forster has further ambitions: "We're also seeking MRO opportunities and examining the airport's real estate and sustainability. From the sustainability angle, we want to be doing as much as possible with the airport regarding revenue development, but we want to get it right as well. So we're looking at putting in a solar farm across the airport estate and we want to be the first UK airport to be fully off the grid from a sustainability point of view. Not only will this help our airline partners, but it will also help potential real estate tenants."

"The real big push we have focused on is utilising the airport business park, which we predict over the next ten years can bring in up to 4,500 jobs and provide £450m to the Tees Valley economy. We have brought

in FedEx, so we have the world's largest transportation company that has both road and air networks and currently flies eight times a week to Paris/Charles de Gaulle. We want to continue to grow the cargo throughput on site."

It's clear from Forster's passion for developing all aspects of Teesside International Airport that it will be a success, with plenty of opportunities for local and international companies to be part of its growth. *Air International* asked Forster how long it had taken from the earliest discussions with Airborne Colours to the unveiling of its new facility: "From when we picked up the conversations after COVID, when the world got back to normal, it was around 18 months. That included getting the terms agreed and ensuring that there was the necessary skill set in the region."

"Teesside Airport is growing in passenger numbers and we've set a high standard of getting to the one-millionth passenger mark. I want to see us doing well in terms of the world of cargo, but I don't want to be looking to create competition for all my current business partners. I want to learn how I can help them grow. I would like to see more MRO companies here, because I want the airlines to know that we can offer that one-stop shop, so you can come and get your aircraft painted, have it torn down and have it maintained. And you can also get a fabulous deal with the airport in terms of flying from here."

Based on the business plan that Forster and shareholders have for the airport, Teesside International will soar in the future, not only in terms of passenger flights but in every aspect of ground support. **AI**

Helicopters in safe hands at Yeovil



Recognised as the home of British helicopters, Leonardo in Yeovil is the nation's only onshore end-to-end helicopter design and manufacturing facility. The OEM has recently secured its position in the global helicopter market by officially opening a £30m single-site logistics hub for helicopter maintenance on September 18. The brand-new plant integrates eight previously used buildings into one state-of-the-art facility. Built in collaboration with Kuehne+Nagel, it draws on their expertise in green technologies to make sustainability a driving factor within the building.

According to Adam Clarke, managing director of Leonardo Helicopters UK, the hub will revolutionise how Leonardo services its global helicopter fleet by helping the OEM deliver replacement parts more efficiently and on time. It is equipped with LED lighting throughout, along with a bank of electric vehicle charging points supporting Leonardo's Green Travel plan for employees and a brand new fleet of electric commercial vehicles that will distribute components from the plant to the company's manufacturing facilities. There is also a heat recovery system

"We are proud to open this impressive new Single Site Logistics Hub here in Yeovil, the Home of British Helicopters," said Adam Clarke, managing director of Leonardo Helicopters UK
Leonardo

in the main warehouse to complement the temperature control system in the building's modern offices.

During the opening ceremony, Clarke said: "This strategically-located facility will be able to draw on the region's robust supply chain and skilled workforce and, by incorporating the latest digital and automation technologies, will enable us to offer an even better maintenance service for our UK and international customers."

Mark Langrill, DE&S director of helicopters, said: "We welcome Leonardo's development of their new logistics hub and applaud their focus on sustainable design. Such investments in skills and infrastructure are an important means of contributing to regional prosperity and, in this instance, improving support to some of the UK armed forces' helicopter fleets, procured by DE&S, which play an essential role in defending our national interests."

Murray Gascoyne, national contract logistics director at Kuehne+Nagel, commented: "Following four years of partnership with Leonardo Helicopters UK, we're delighted that the single-site

fulfilment has been officially opened. Our shared strategic vision has come to fruition. This has been founded on, and testament to, our unwavering commitment to sustainability, the development of people skills and the power of collaboration. We are very proud to be part of the Yeovil community."

The Hub will support the 3,330-strong workforce, which includes 430 design-focused engineers at the site. Speakers at the opening pointed out that they are "proficient in the 87 essential skill sets for executing high-value helicopter design work."

The sheer scale of the new logistics hub cannot be overestimated, with rows of shelving racks containing engines and parts and wall racks containing prepared Merlin and Wildcat blades waiting to be moved to Yeovil's engineering and production lines when needed. The efficient use of space and storage indicates that the OEM believes it has much to offer the global helicopter market, and the enthusiasm of senior managers and partners was evident. Now, it's a case of Leonardo awaiting the outcome of the UK's decision regarding the new medium helicopter programme – Leonardo's plans are already in place for when the UK Labour government announces a final decision. **AI**





The **power** curve

OEMs have produced technically excellent engines, but **Michael Doran** says they are not staying on the wing long enough

The CFM LEAP has logged more than 50 million flight hours since entering service in 2016
CFM



ABOVE:
The GTF Advantage will cut fuel consumption and lower emissions when it enters service in 2025
Pratt & Whitney

RIGHT:
Pratt & Whitney has 18 GTF MRO shops globally, with two more being added in 2025
Pratt & Whitney

At the end of August 2024, Boeing and Airbus had a combined backlog of more than 14,000 aircraft. Without accounting for spares or replacements, that's another 28,000 engines that OEMs have to make, test, deliver and support.

Issues with engine durability and the availability of parts, materials and technicians to repair them have resulted in hundreds of aircraft sitting on the ground. At a time when demand is at a peak, this is costing airlines and airports a small fortune and disrupting schedules.

Air New Zealand reported its half-year earnings in August and profit had dropped by more than 60% year over year. CEO Greg Foran said £47m was lost in the six months because nine of the airline's best aircraft were out of service due to engine issues.

Having invested in new-generation aircraft, it must be disappointing to have six Airbus A320neo Family and

three Boeing 787-9s grounded, forcing routes to be cancelled or flown with 777s that burn more fuel, emit more carbon and cost more to operate. Even more disappointing is that the promised performance gains from new engines have been more than met, but that's of no consequence if the engines have to be removed far earlier than scheduled and do not return for up to 300 days.

In 2008, Pratt & Whitney officially launched its revolutionary GTF 1100G geared turbofan, a family of new-generation high-bypass engines destined for use on Airbus A220 and A320neo Family aircraft and Embraer E-Jet E2 regional jets. The engine promised significantly reduced fuel consumption and carbon emissions, meeting or exceeding its promise of fuel savings of around 16-20%. The first GTF 1100G entered service in January 2016 on a Lufthansa A320neo, but then a string of issues resulted in the new aircraft sitting on the ground without engines.

Once the entry-into-service (EIS)



Singapore's ST Engineering is part of the global CFM LEAP service network ST Engineering

GE invests in MRO capability

With an installed base of more than 44,000 commercial aircraft engines, GE claims an airliner powered by GE Aerospace or one of its partners takes off somewhere in the world every two seconds. As the main story highlights, keeping all those aircraft in the air is no easy task. To make that even more specific, GE is investing \$1bn in its global MRO network over the next five years. All 19 of GE's MRO and component repair sites will be upgrading equipment and machines, purchasing new tooling, expanding and improving facility infrastructure and accelerating repair technology advancement.

Farah Borges, VP of assembly and test,

maintenance, repair and overhaul at GE Aerospace, said the key is to provide customers with a differentiated experience and "make sure that when an engine is removed from a customer's wing, we perform high-quality maintenance and get it back to them as soon as possible. Traditionally, on-wing support [OWS] has focused on meeting customers where they are and performing repairs on-wing or near-wing. Over the past couple of years, we've done more quick turn-off-wing work at these sites and the capability at our OWS sites will be a large part of how we support light work scope engines."



issues were overcome, the GTF settled into a few years of solid output and performance. Still, for the last year or so, durability issues have surfaced, leading to more than 350 grounded Airbus A320neo Family aircraft.

The GTF has been a gamechanger, using up to 20% less fuel, producing 50% fewer emissions and reducing noise output by 75% compared to its predecessors. The problem is that too many GTFs spend excessive amounts of time off-wing. Most recently, the issues have resulted from contaminated metal powder used in manufacturing some parts, leading to mandated inspections. This has been exacerbated by supply chain and parts shortages, resulting in some engines being off-wing for more than 300 days.

Amy Comer is vice-president of GTF Programs at Pratt & Whitney (P&W). She gave *Air International* some valuable insights into the remediation programme and how the manufacturer is quickly bringing more engines back into service: "At the end of Q2, we have inspected more than 6,000 powder metal parts in the field across all programmes, and the associated fallout rate remains below the 1% we had assumed. At our MRO facilities, the throughput of engines continues to improve and overall capacity is expanding with the recent addition of two new MRO shops into the network."

The availability of more maintenance, repair and overhaul capacity and spare parts has reduced the number of grounded aircraft. P&W has reached support agreements with 20 customers, covering around 65% of the impacted fleet. The GTF MRO network now has 18 active sites globally and two more are expected to come online by 2025.

Since the GTF entered service, P&W has developed and implemented various upgrades to respond to issues seen in the field. Comer said the GTF demonstrates better durability than other new engines at similar stages in their lifecycle, but added: "We are still not meeting our customers' or our expectations."

P&W is already planning further durability enhancements, including an optimised cooling configuration for the combustor and high-pressure turbine and an advanced turbine airfoil with improved coatings. The popularity of the A320neo means GTF engines operate in every conceivable environment, sometimes producing durability issues not seen with older generation engines: "We are fully committed to continuously advancing the GTF, both in terms of enhancements to durability and as a central pillar of our technology roadmap for driving efficiency in future generations of commercial aircraft. We also expect MRO ramp to continue this year and accelerate into 2025 and 2026."





Addressing the durability issue has been a massive effort for P&W, and the company has been focused on meeting the increasing demand for aftermarkets and supporting the GTF fleet and its customers: "We are working with suppliers to increase material flow, hiring hundreds of employees and inserting new technologies in our facilities to increase operational efficiency. We're optimising workscopes, developing new part repairs and sharing best practices to drive innovation throughout the network."

Next year, P&W will introduce the GTF Advantage, the latest generation of its geared turbofans. This engine will deliver up to 1% better fuel efficiency, lower CO₂ emissions than the current GTF and 4-8% higher take-off thrust for more payload and longer-range capability.

CFM International (CFM), a joint venture between GE Aerospace and Safran Aircraft Engines, is competing with P&W for the lucrative engine market for the A320neo Family. CFM produces the

LEAP family of engines, which are fitted to all variants of the Airbus A320neo Family, Boeing 737 MAX and COMAC C919 single-aisle aircraft. The LEAP entered service in 2016 and is now used by around 160 operators, who have since logged more than 50m flight hours and 25m flight cycles. This new engine had its own EIS issues, although a programme of quick turn or 'hospital' visits to MRO shops alleviated many of them. In common with the GTF, CFM has developed engine upgrades to meet issues that have emerged since the engine was introduced more than eight years ago. The latest is an improved high-pressure turbine blade that will minimise early engine removals, particularly in harsh and hot environments.

With more new-generation aircraft such as the 737 MAX and A320neo operating in the Middle East, India, Africa and Asia, engine makers have learned that durability can become an issue in harsher conditions. The engines are not failing,

but they need MRO attention much earlier than was the case with previous-generation engines, such as the CFM 56 and IAE V2500.

In April, the LEAP program general manager, Karl Sheldon, said the LEAP engine family had undergone the fastest ever ramp-up of engine flight hours in the industry, which "has enabled the company to learn things about the engine faster."

He continued: "One of the most important things we have learned is that the LEAP engine design is stable. We've resolved issues that had been driving higher maintenance burdens and early removals [and], as a result, we've been able to decrease the maintenance burden by 55% since the entry into service."

An excellent example of this evolving development is that CFM is now shipping new LEAP-1A engines (used on the Airbus A320neo Family) with a reverse bleed system (RBS) designed to reduce or eliminate on-wing fuel



nozzle replacements related to a build-up of carbon deposits. Cooling air is circulated through the engine's core and around the fuel nozzles to lower the internal air temperature below the level at which carbon deposits can build up. When engines are shut down, the RBS automatically activates and switches off after a specified amount of time or when the engine is restarted.

The P&W issues that have grounded hundreds of Airbus jets have seen more airlines opt for the LEAP engine on A320neos. CFM has secured a raft of large orders so far this year – standouts include an easyJet order for more than 300 LEAP-1As and one from India's Akasa Air for more than 300 LEAP-1Bs. CFM has a backlog of orders for more than 10,000 engines, adding to the LEAP engines currently fitted to around 3,300 aircraft. In July, the CFM LEAP gained European Union Aviation Safety Agency (EASA) certification for use on the Airbus A321XL, the long-range variant of the

Airbus A320neo.

Rolls-Royce Civil Aerospace has also been through a challenging period. The company specialises in producing large engines for widebody commercial airliners. Aside from the COVID-19 pandemic, the company has been battling severe reliability issues with some of its Trent engines, particularly the Trent 1000 that powers Boeing 787 Dreamliners. These entered service in 2011 and are one of two options for the Boeing 787, competing with the GE Aerospace GEnx.

The Trent 1000 had a troublesome start and, in 2016, Rolls-Royce introduced the Trent 1000 TEN, which is now suffering from durability issues and decreased maintenance cycles. Air New Zealand was the launch customer for the 787-9 and took its first of 14 Dreamliners in July 2014. The airline grappled with engine problems for more than two years and is still dealing with 787s grounded due to a lack of Trent engines, causing it to suspend lucrative long-haul routes. In March, the airline had to suspend its 787 flights between Auckland and Chicago due to ongoing engine problems, including a lack of replacement parts, MRO capacity and spare engine availability.

Air New Zealand said the Trent 1000 engines typically require heavy off-wing maintenance after 1,000 flight cycles. However, during regular inspections by engineers, they found the engines needed to be taken off the 787s after 750-800 cycles. Rolls-Royce advised the airline that it had no replacement engines or capacity to repair the existing ones, so the airline has trimmed its schedules, suspended flights to Seoul and grounded three 787-9 Dreamliners.

Rolls-Royce has developed a new durability enhancement (DE) package with a re-engineered high-pressure turbine blade to increase the Trent 1000's time on the wing. Improving the blade's cooling performance has more than doubled its life and will extend the time between major maintenance and time off the wing. The upgrade is due for production in early 2025 and customers with existing Trent 1000 TEN engines that pre-date the introduction of the DE package will also benefit. It will be installed into their engines at their first scheduled maintenance and complete refurbishment under every customer's TotalCare programme.

A second package of hot-section enhancements is in development and Rolls-Royce said it would deliver a further improvement in time of up to 30% on the wing. Understandably, Air New Zealand has endured enough and has instead specified GEnx engines for the eight Boeing 787s it has on order.

On the other hand, Rolls-Royce



“At our MRO facilities, the throughput of engines continues to improve and overall capacity is expanding”

Amy Comer, vice-president,
GTF Programs, Pratt & Whitney

LEFT:
CFM International replicate multiple operating environments, such as this icing test on a LEAP engine
CFM





The Rolls-Royce Trent 1000 TEN is suffering from durability issues and decreased maintenance cycles on 787s
Rolls-Royce

is enjoying success with its Trent XWB engines fitted to Airbus A350s and Trent 7000s on A330neos. In April, it signed an order with Indian carrier IndiGo for 60 XWBs and confirmed orders from Vietjet for 40 and Virgin Atlantic for 28 Trent 7000s, the sole engine option for the A330neo. In the first half of 2024, Rolls-Royce received orders for 273 large engines, increasing its order book by 9% to 1,773 engines at the end of June 2024. With 108 orders, the Trent XWB-97 was the bestselling engine in the first half of the year, and the company delivered 236 engines, including 120 large and 116 business aviation engines.

As producers of large engines, Rolls-Royce and GE Aerospace (GE) have suffered from the slow resumption of international travel post-pandemic. With widebody aircraft grounded for longer, the OEMs lost revenue from their Power By The Hour customer care packages. Issues with the 787 and the suspension of work on Boeing's new 777X presented more problems for GE, but now there is progress on both the GEnx and GE9X platforms. The GEnx powers two-thirds of 787s in service and has logged more than 56m flight hours since launching in 2011, with more than 3,000 in service or on backlog. The GE9X, which received certification in 2020, is the exclusive engine option for Boeing's 777X and is the quietest GE Aerospace engine ever produced per pound of thrust. It offers industry-leading NOx emissions reduction for its class and, like all GE engines, is compatible with any approved sustainable

aviation fuel.

Amid its 737 MAX and 787 manufacturing dramas, Boeing paused work on the 777X, but it restarted in July when it started certification flight testing of the 777-9 with US aviation regulators onboard. Type inspection authorisation happens at the start of the certification process and comes after the Federal Aviation Administration (FAA) has examined the aircraft's technical data. That approval allows FAA pilots to participate in the flight testing required to certify the aircraft for regular service. The 777X is not expected to gain FAA certification until the first quarter of 2025, but with the aircraft now back in the air, GE will have a renewed sense of confidence in the GE9X project.

At the Farnborough Air Show in July 2024, Qatar Airways increased an existing order for 777Xs to 94 commercial and cargo aircraft. While these are a mix of orders and purchase rights, the announcement contains orders for 70 GE9X engines. In March this year, GE also secured an order for 16 GE9X engines from Ethiopian Airlines to power its fleet of 777X aircraft, becoming the first GE9X customer in Africa. GE also has GE9X orders from Singapore Airlines (62), Lufthansa (18), Air India (20) and Silk Way West (16).

Meanwhile, the Air India order includes more than 800 CFM Leap engines to power the purchase of 210 Airbus A320neo Family and 190 Boeing 737 MAX jets, as well as 40 GEnx engines for 20 787 Dreamliners. **AI**

THINKING INSIDE THE BOX



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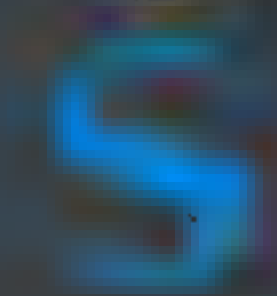
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Beautiful disruption

The latest configuration of the Eviation Alice has been confirmed and the company is looking forward to getting new prototypes into the air. The company's CEO, Andre Stein, discusses progress with **Bernie Baldwin**

“When you look at electrification, it's a beautiful case for disruption because batteries are not ready or may never be ready for larger aircraft.” So declares

Andre Stein, CEO of Eviation, which is in the process of bringing its nine-seat electric aircraft, Alice, to market.

In development since the end of the 2010s, Alice has a target range of 250nm purely on battery power and a maximum operating speed of 260kts. Aimed at the regional market, there is also a cargo variant, and both models have garnered orders.

prototype

seeks wonderland destination



An early design with a V-tail was displayed at the Paris Air Show in 2019. While a fire destroyed that prototype and, by 2021, a new Alice design had been revealed with the T-tail that remains part of the current configuration.

Stein picks up the story at the current stage of the planned industrial timeline: "We finished our conceptual design review

(CoDR), which we announced in late April, and throughout this year, we'll be refining the design. Also, we are interacting with partners and selecting the main suppliers. We are really focused on developing the production aircraft because one of the goals of the conceptual design was to ensure we have something that's certifiable, manufacturable, and to put it on track for that."

Eviation revealed the latest configuration for the Alice all-electric commuter aircraft on April 24, 2024

All images via Eviation



CLOCKWISE FROM ABOVE

Customers for the Alice include DHL Express, Flyvbird, Solyu, Cape Air, Evia Aero, Air New Zealand, Aerus and cargo carrier GlobalX

This is the second time that Eviation has redesigned the Alice aircraft since it revealed the initial concept in mid-2019

Alice's fully electronic flight deck, is complemented by touch screen flight displays





“When you look at electrification, it’s a beautiful case for disruption because batteries are not ready or may never be ready for larger aircraft.”

Andre Stein, CEO, Eviation

Among the new design features introduced for the aircraft that will go into production are:

- **A constant cross-section that reduces Alice’s parts count and manufacturing costs while also increasing the potential for future variants of the aircraft**
- **Structural segments designed for field reassembly with standard tooling available for maintenance, repair and overhaul services**
- **A larger, centralised energy storage system (ESS) compartment above the wing that can integrate a range of ESS solutions now and in the future, in addition to streamlining certification**
- **An optimised cabin space allowing for a side-mounted carry-on stowage compartment, claimed to be unique in the commuter class**

Other programme milestones achieved so far include receiving the G-1 Issue Paper from the US Federal Aviation Administration in 2021, which establishes the airworthiness and environmental

requirements necessary to achieve type certification.

In September 2022, Eviation successfully completed the inaugural flight of the first Alice prototype, which the company declared to be “a historic day and a major milestone in electric aviation”. The conceptual design review means that the aircraft that goes into production will differ somewhat from the aircraft that flew.

Regarding selecting the leading suppliers, Stein expects most of those to be decided and announced this year. “That would be the flight control systems, engines, batteries, avionics and so on,” he remarks. He also confirms that although the prototype flew with a magniX powerplant, Eviation is still talking “with several potential suppliers”.

Once the suppliers are fully on board, thoughts will turn towards the certification flight test campaign. “Before that, though, there is a lot that needs to be done in terms of designing and manufacturing rigs as well as carrying out ground tests so we can ensure that we are on the right track with the aircraft,” Stein notes.

“Flight test campaigns typically take about 18 months. What we’re doing differently, though, is that most Part 23 aircraft typically would have three prototypes, but we’re increasing this number to take into account the fact that it is a short-range aircraft that’s electric. So we expect to have five prototypes,” he explains.

“One of the things that’s interesting about this programme is that even though it’s electric – which brings its own challenge – it is a very pragmatic approach. Although it’s a bit off the beaten track in terms of development and certification, it’s very different from the urban air mobility scenario where that segment needs a change in regulations to exist,” Stein highlights. “We are following the traditional Part 23 certification. That means we don’t have to reinvent the wheel in terms of the gates on the process. That makes life much easier to achieve both the certification and the entry into service, the target for both being 2028.”

Every aspect of the aircraft was part of the recent review, so Stein discusses



the interior options, including the cargo version, about which he is enthusiastic. "That's one of the great outcomes of the design review. One of the things we've done is to relocate the battery on top of the wing in the back. Before, it was on the cheeks of the aircraft. The change allows us to reclaim that space inside the cabin for storage. It'll be the first aircraft of this category to have carry-on-board capability.

"We also improved the cross-section. It was already the best in the category, but we've improved it, increasing the head clearance for the passengers with the new height of the aisle," he continues.

"It is a constant cross-section that allows you to have the same passenger experience in the front and last rows. So, there are quite a few improvements there.

"On the cargo side, we revised the cargo door to align it with the structural ribs of the aircraft. That allows for an easier retrofit to start with, but also, it's a bigger cargo door that allows a pallet to get in and out," Stein reports. "Also, the height of the door is lower than the version that has flown. That allows people to load luggage inside without the need for ground support equipment."

The CEO points out the value of all the extra interior baggage storage for connecting passengers. "It will enable them to pick up their bag and walk off seamlessly to head to their next aircraft,"

he comments.

With the conceptual design review done, customers now know exactly what they will receive when their aircraft are delivered. And so far, the total order stands at 605. "That's around \$5 billion in the backlog," Stein notes. "One of the impressive things about the order book is that it's not one single customer or one single geography. It's spread around between traditional airlines like Air New Zealand and Cape Air and newcomers like FlyV, which is changing the on-demand market.

"That's one of the great things about this market segment. It's really affected by the Uber-of-the-skies approach because it's the right size to do on-demand in a very different way than the traditional air taxis. So, we have traditional airlines, cargo, [all] on-demand. We have lessors like Monte – one of our customers – that allow us to address that market and a very well-spread geography. We have customers in Asia, Europe, the US, and Latin America."

Stein takes a cautious path in determining the location of the intended production facility for all those orders. "One big lesson I have learned is that the aircraft comes before the production facility, meaning that sometimes you see investments too early in that area. So, we'll invest in infrastructure at the right

time to have the aircraft enter the market in 2028," he explains.

That's not to say plans are not underway. Decisions are expected during 2025, and the company is currently in talks with different states in the US about the production facility.

"There are a lot of incentives out there, particularly with Alice being a sustainable aircraft," Stein reports. While steering clear of the politics associated with the upcoming US election, he expects that some states might change their tack – both for and against – regarding incentives with a new state-level regime.

One element of US politics that Stein finds "very positive" was the recent Reauthorization Bill for the Federal Aviation Administration (FAA). "Two specific areas are very interesting for us. One is industrialisation, but the other one is actually the big focus – retrofitting and restructuring smaller airfields for regional service, particularly the smaller end of the market that has been losing service for years, which creates a great case for us," he emphasises.

Stein's remark reflects the position of the Regional Airline Association (RAA), which has repeatedly pointed out how many communities have lost their connectivity. Getting that connectivity back is a significant role for aircraft such as Alice.

"That's actually one of the reasons I

In cargo configuration, Alice offers 450 cubic feet. The aircraft is equipped with forward and aft access doors as well as a secure webbing system, designed for swift turnarounds



joined. I believe that particular market segment is ripe for disruption," he declares. "It needs a solution that brings a different level of operational costs. The nine-seater helps us to address that, even with crew costs, because it's a single-pilot operation.

"Also, passengers are a bit fed up with taking two hours in the airport to go through all the security protocols to get on board. It's not necessarily different in terms of protocol in a smaller airport, but it's just fewer people. It brings flights closer to customers. That applies not only to smaller communities but also to smaller airfields in bigger metropolitan areas. If you go to the Bay Area, you could fly from Palo Alto directly to Lake Tahoe rather than drive to San Francisco International, fly to Reno and catch an Uber on both sides. That point-to-point rather than hub-and-spoke approach recreates a lot of this connectivity in terms of convenience because if you need to start driving around to different airports to get a flight, you might as well drive all the way," Stein elaborates.

Similarly, he believes that another operation to replicate is that of Cape Air, which has been flying small aircraft successfully for some time and is a major Eviation customer. "That's a great model. There are many areas around the country – like the area where they fly around Boston – where flying is the best

travel mode. In Europe, too, there are a lot of underserved communities that don't necessarily have the road infrastructure or enough density for a high-speed train. In Europe, I often hear, 'Oh, but you guys are competing with the high-speed train for this short distance. You cannot beat that.' That's not necessarily true. Not everybody is competing with the high-speed train."

The geography of Europe, particularly around the Alps, underlines his point. Flying over fjords and other expanses of water up in the north is another example. "That's why I'm excited by the programme; it will connect smaller communities without the stigma of using Jet A-1," Stein states. "Flight shaming is particularly strong in Europe. We address that straight away because we are replacing traditional fuel operations with a sustainable fuel solution."

Alice's sustainability extends beyond being emissions-free; it covers other elements of the aircraft, particularly the batteries. "For that size of aircraft and that type of range, state-of-the-art batteries with existing technology will do. And they are a replaceable item, so that's a first in aerospace, with the aircraft you buy actually improving in performance with time," Stein explains.

"With a newer generation battery, you either put in a smaller, lighter battery

and have the same range but with more payload, or you put the same weight and size of the battery, but of course, it's more powerful, so it increases the range for the same payload," he adds.

Returning to production will likely be a challenge ahead as all OEMs vie for parts, components, and even raw materials, not just in the aerospace industry. "The automotive industry is getting a lot of batteries and increasing its demand. Aerospace's volume compared to that is a tiny fraction, but it's a fraction that's on the high-value end. So, if you are going to put material in a battery, it makes more sense business-wise to go with aerospace where there are better margins," Stein remarks. He believes the same rationale applies to other aircraft parts, too.

"Parts for prototypes is not much of an issue. We really start talking about full production a few years from now. It's when we start to scale the production that it could become an issue. But that's still a few years ahead, and the situation is way better now than it was a couple of years ago when there was a big shortage."

Airport infrastructure is another area which needs concerted forward planning. Although not under Eviation's control, it is important that airports will be ready to handle Alice. "We have several discussions ongoing," Stein confirms. "It's less of an





“The change allows us to reclaim that space inside the cabin for storage. It’ll be the first aircraft of this category to have carry-on-board capability”

Andre Stein, CEO, Eviation



infrastructure issue than other advanced air mobility solutions because we can basically operate under the existing infrastructure, other than the fact that you need a charger. Airports have electricity – the grid is there – and for the chargers, we are talking with several potential partners to ensure that they are there too.”

For recharge times, the equation is simple, according to Stein. “It’s about one-to-one, so every minute of flight is about one minute of recharge.

“Just going back to the point on infrastructure, that was also another big part of the Reauthorization Bill. There is a focus on regional air mobility, and investment in infrastructure for regional airports is included. There is, therefore, an opportunity there to use some of these funds to retrofit the airport, not only paving the runway again but also adding the required infrastructure necessary for electrification.

“Another interesting point is that airports tend to be great locations for solar power,” he observes. “So among the partners we are in discussions with, we have some players that are already offering that option as part of the overall solution. If we have the solar grid in the airport, we can charge the aircraft with local generation, which is good in so many ways.”

One of Eviation’s customers, Cape Air, is already working with a solar farm — though not actually at an airport — that is not far from the airline’s headquarters. The carrier says it has that power lined up to charge its aircraft from solar power. Many airports are already putting solar panels on their roofs. Adding some to hangars won’t take much, too, so more solar power can



CLOCKWISE FROM ABOVE:
Up to 2,500lb of cargo can be carried on the Alice, which now has a constant cross-section giving, a more typical fuselage shape

The Alice is designed to carry nine passengers on distances of up to 250nm

The redesigned Alice has an updated interior that has more space for passengers. The new layout provides overhead bin space for passengers to store their luggage

More than 600 aircraft are on order from some of the world's major airlines and air charter companies



THIS IMAGE:

Alice is the first ever all-electric commuter aircraft that will change the way people and goods travel regionally through zero-emissions flight

BOTTOM:

Eviation completed a major milestone towards Alice's certification and entry-into-service with the completion of wind tunnel testing at the University of Washington's Kirsten Wing Tunnel in Seattle in March 2024. More than 400 runs were completed and almost 9000 individual test data points, the testing validated Alice's production design



be fed into the local grid.

"One of the main points is that we are seeing more and more appetite for discussing regional advanced air mobility. It requires a much more pragmatic approach in that you are addressing an existing market with a lot of upside. But it does exist as a very resilient market, sometimes being served by very old-generation aircraft. It's ripe for disruption, and with that, it creates a base," Stein states. "Then you add things like the on-demand aviation, and then cargo increases through the expectation of next-day delivery or even same-day delivery. That cannot be achieved with default aviation. Players like DHL, one of our partners, can address this mid-mile demand with a smaller aircraft that became even better for cargo with

that revision of the interior and cabin I mentioned. We now have a bigger cabin, a higher volume of cargo, a bigger passenger, a bigger cargo door, a more effective cargo door, and a flat floor throughout the aircraft; all that helps that segment that, like the passenger segment, is right for disruption."

It was in early 2024 that Stein took on the Eviation CEO role. This move was noted around the industry, given his experience in helping to launch regional aircraft during his time at Embraer. "One of the things that's really attracted me to the whole concept, when you look at regional mobility, is that it has been growing up. And that is the casebook for disruptive innovation," he notes.

"The entry-level of the segment has been going up and up, the costs are

going up, and the hurdles are going up, like the security measures in airports and so on. So, the entry-level that used to be the 19-seater aircraft became the 30-seat turboprop, the 50-seat jet, the 70-, 80-seater, and the 100-seater. It kept going up, and it needed something to disrupt it."

Stein comes back to his original point about electrification being a beautiful case for disruption and sums up Alice's entire raison d'être. "Batteries won't work in an aeroplane that carries hundreds of people for thousands of miles, but you can use that technology to lower the entry point and fly fewer people not that far. One-third of all routes worldwide are less than 250 miles, so there is a massive market right there to be addressed," he concludes. **AI**



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Airbus's game

With the A350-900, Airbus is
challenging the A380's dominance
in the ultra-long-haul market.

Mark Broadbent reports

The Airbus A321neo is the bestselling variant in the A320neo family, with 6,503 orders by the end of August 2024. Simultaneously, the baseline A320neo had 4,011 orders and the smaller A319neo just 67.

The reason the A321neo has done so well commercially is because it offers efficiencies from earlier-generation single-aisles – 30% lower fuel burn per seat and 15% better cash operating costs, claims Airbus says – and because it chimes with airlines' preference for larger single-aisles.

A new variant, the A321XLR (Xtra Long Range), is set for service entry in the last quarter of 2024 following European Union Aviation Safety Agency type certification in July 2024.

Launch operator

The A321XLR's 4,700nm range makes it the longest-range single-aisle airliner ever developed. Iberia will be the first operator and its initial aircraft is EC-OIL (msn 11504). The delivery date remains unconfirmed, but the Spanish carrier has tentatively planned November 14, 2024, as the operational debut for the aircraft on its Madrid-Boston/Logan route. A second Iberia A321XLR route (Madrid-Washington, DC) is scheduled to start in January 2025.

Iberia will receive seven of the 13 A321XLRs ordered by the parent company, International Airlines Group. Another IAG airline, Aer Lingus, was originally earmarked for these aircraft, but uncertainty over costs due to a pilots' pay dispute led IAG to revise its allocation →

The first A321XLR test aircraft receives a water cannon salute ahead of its first flight in 2022

H. Jansen/Airbus



changer?



plans. (An August 2024 agreement with pilots' unions has put the A321XLR back on the agenda for the Irish carrier.)

American Airlines expects to receive its first A321XLR in December 2024. Deliveries to several other customers – Air Canada, IndiGo, JetBlue, Qantas and Wizz Air – are scheduled for 2025.

Airbus launched the A321XLR at the 2019 Paris Air Show, with orders and commitments for 249 examples from customers, including American (50), IAG (13), Qantas (20) and United Airlines (50). Although the orders announced at the show were conversions from existing A320neo Family orders rather than entirely new business, they showed there was demand for a new mid-size aircraft (220-280 seats, around 5,000nm range) offering cost/efficiency improvements from earlier-generation aircraft in the segment, most notably the Boeing 757.

The impact of the COVID-19 pandemic on international air travel and subsequent uncertainties over demand did not

dampen the A321XLR's appeal. Orders were placed by AirAsia X (20), Air Canada (30), Icelandair (13), JetBlue (13), and, perhaps most eye-catching, low-cost carriers IndiGo (69) and Wizz Air (47).

Rear central tank

The A321XLR features the same new-generation CFM International LEAP-1A/Pratt & Whitney PurePower PW1100G-JM engines, optimised aerodynamics and the Airspace cabin as the baseline A321neo.

The aircraft evolved from the A321LR (Long Range), which has a 4,000nm range thanks to a third 2,992-litre auxiliary centre fuel tank and a higher 97,000kg maximum take-off weight (MTOW). The A321LR first flew on January 31, 2018, and its operators include Aer Lingus, Air Transat, Arkia Israeli Airlines, Gulf Air, TAP Portugal and SAS.

The A321XLR had its maiden flight on June 15, 2022. It builds on the A321LR by offering a 4,700nm range and a 101,000kg MTOW. But while the LR's range results from two additional centre tanks that are activated/deactivated as required, the XLR's payload/range performance is due to an entirely new rear centre tank (RCT), a permanent high-capacity unit holding 12,900 litres of fuel.

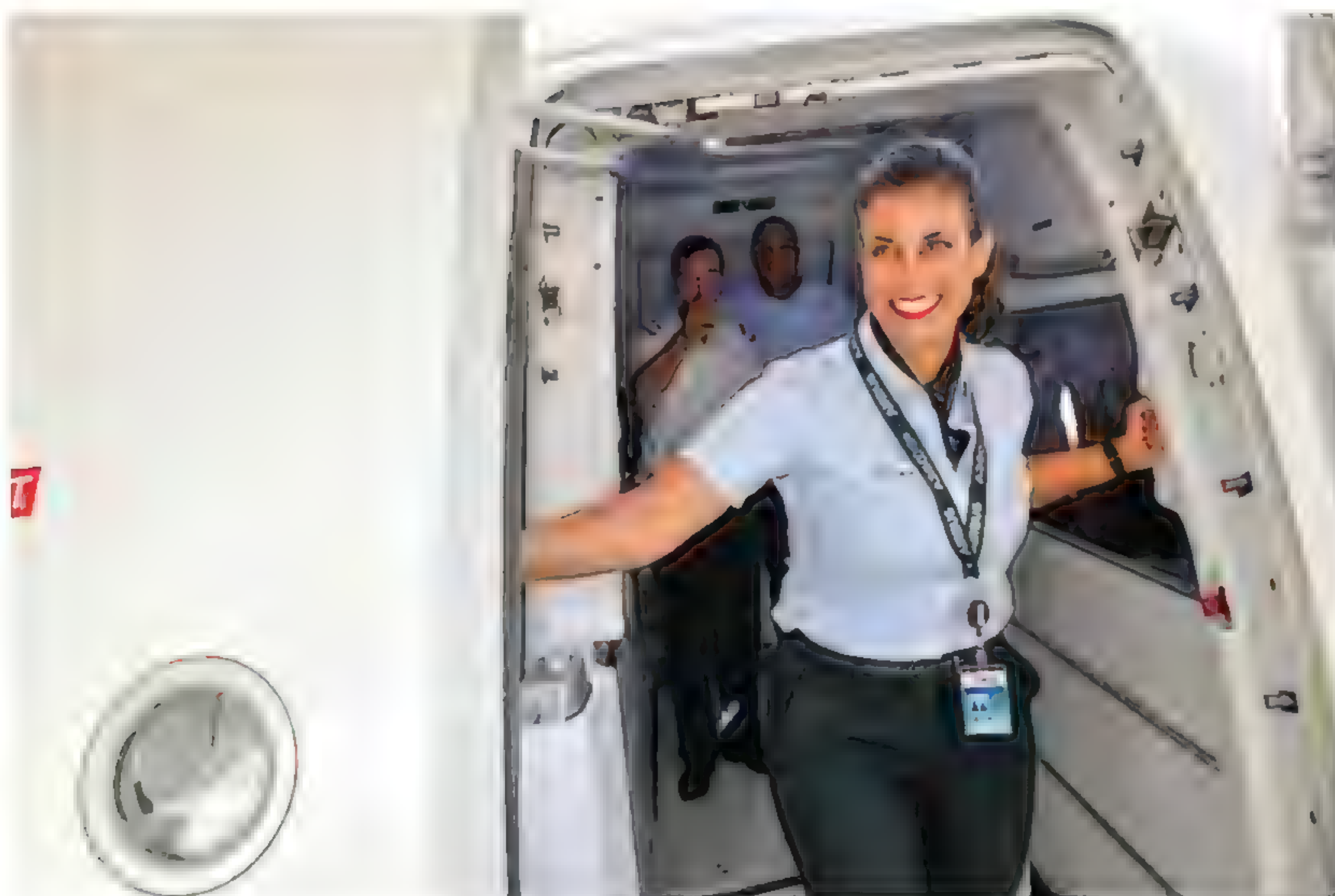
The RCT's front wall sits behind the main landing gear bay, its rear wall ahead of the rear cargo bay. Gary O'Donnell, head of the A321XLR programme, said in a video briefing: "The secret of the tank is we can hold the fuel all the way up to the fuselage skin, so we maximise the amount of fuel we have in this space." The RCT, he said, holds "the equivalent [volume] of four additional centre tanks in the space of two additional centre tanks."

Certification challenge

Airbus originally planned a 2023 service entry for the A321XLR. However, in its Q1 2022 results, the company announced a postponement to 2024 due to redesign work arising from EASA concerns over fire safety requirements. EASA said in July 2024: "The RCT represented a novel, unusual design, that was not fully covered by the existing CS-25 certification specifications, the main technical requirements that have to be complied with in the certification of large commercial aircraft.

"EASA's approach in such a situation is to lay down what is known as Special Conditions to address any gaps or inadequacies in CS-25. The special condition defines safety standards that any manufacturer wishing to adopt this change would have to meet to achieve certification approval, without prescribing exactly how they should achieve this."

The RCT integrated within the underbelly of the A321XLR's fuselage led to EASA developing a Special Conditions set focused on crash safety, fire safety





CLOCKWISE FROM TOP LEFT:

The belly tank, visible in this photo of an A321XLR at Farnborough in July 2024, is significantly different from other A321neo variants

Airbus

Icelandair CEO Bogi Nils Bogason (left) at the 2023 announcement that the carrier placed an order for the A321XLR

Airbus

Florian Guillermet, executive director of EASA, handing over the type certificate for the Airbus A321XLR to chief engineer Isabelle Bloy

Airbus

Iberia is scheduled to introduce the A321XLR in November 2024 on its Madrid-Boston/Logan route

Airbus

The A321XLR presents possibilities for opening new, previously unviable connections

Airbus



and occupant protection.

Michael Singer, head of large aeroplanes at EASA, said: "We needed to be sure that the design location of the tank would not in itself trigger a safety issue. That the tank was adequately robust and crash-resistant, even in a case where the landing gear failed or an unknown threat such as an item on the runway could damage it. Finally, we wanted proof that if the tank were compromised, the leakage rate would be limited so as not to pose a threat."

Crashworthiness

Gary O'Donnell commented: "We worked hand-in-hand with EASA and the FAA while we developed this aircraft. Mid-way through the development programme, we had a requirement to upgrade the crashworthiness, focusing primarily on landing without engines and landing gear. In that belly landing, we have to absorb the crash loads to ensure the aircraft can slide forward."

Airbus responded by providing a

sophisticated tank integration design, making it more crash-resistant. It introduced stronger material compositions and additional supporting structural provisions to protect the fuselage in case of an uncontrolled landing.

The A321's belly fairing was extended by roughly 1.5m, so it finished approximately 50cm from the rear antenna. A protective rubber liner to surround the RCT was also developed. O'Donnell explained: "In the case of a fuselage rupture, the rubber liner will keep the fuel above the rock, so it prevents the leakage [of fuel] in any volume."

O'Donnell said that structural reinforcements were made around the fuselage and in the RCT itself between the roof and floor of the tank "to ensure the fuel does not come out of this tank in any volume that is sufficient to catch fire. If that fuel *does* catch fire, the bottom of this tank, the skin, is made of fibre metal laminate, which is very good at holding back the flame."

He continued: "Normally we design our aircraft to the crashworthiness requirements that exist all through the industry. We have the ability to land on the engines with the touchpoint at the back of the aircraft. We have, on purpose, placed the RCT in a space that would never normally touch the ground."

A321XLR development also involved extending the baseline A321neo fuel system to connect the RCT to the centre wingbox, introducing new pipes in the starboard wing that vent air from inside the RCT: "We have the ability to push the air out through the right-hand wing so the fuel can be filled in the quickest possible time. We also have a full inerting system on the RCT and the centre wingbox, which ensures the latest protections for explosion requirements."

Landing gear

The A321XLR features an entirely new ➔





main landing gear. O'Donnell said: "We have taken the opportunity to simplify the suspension inside the landing gears; we have a single-stage oleo. On the current A321, we have a double-stage, so a double spring, which means we can simplify the maintenance and service."

The nose landing gear was also reinforced: "Because of the [increased] MTOW, we have new wheels, tyres and brakes on both landing gears. In the future, some of these aspects will be moved back onto the A321 fleet to ensure we have commonality across the A321s, where possible."

The A321XLR's inboard flaps are single-slotted rather than double-slotted: "The inboard flap has been simplified. We have been able to tune the flight controls and upgrade the flight control software to give us the same ability to fly and take off using more simple flaps. We get a weight saving to counteract the airframe structural increase. We also give a benefit to the airlines with a more simple mechanism."

Outboard flaps have been reinforced to take the higher loads: "We'll look at how to make these flaps as standard as they can be across the fleet. We're looking to minimise the number of specific spare items [airlines] need on an XLR versus an A321 today."

The RCT means the electronic cables run from the cockpit to the rudder on a standard A321 could not be included in the XLR, so Airbus carried its e-rudder (electronic rudder) technology over from the A350 and A330neo. Another difference from the standard A321neo is an additional water tank in the forward fuselage (taken from the ACJ321 variant) that carries 400 litres of potable water.

O'Donnell explained: "Once you increase the fuel tank, you increase the weight, you increase the systems and you have to consider passenger comfort over this extended period. We've had to increase the thermal insulation around the fuselage to make sure the cold air from those extra couple of hours [on a long-haul flight] does not penetrate the cabin.

Additionally, we have three heated zones versus the two we have on the A321. Each of the doors has heated floor panels and we have optional floor panels in the forward section. This gives us very good thermal comfort."

According to EASA, the A321XLR certification involved the regulator and Airbus holding more than 400 joint meetings and the three test XLRs amassing 900 flight test hours. More than 500 certification documents were produced, reviewed and signed off, tests were witnessed, inspections were carried out and audits were completed.

Heir to the 757

John Strickland, director of JLS Consulting, said to *Air International* that when the A320 Family was first developed back in the 1980s "nobody would ever have imagined it would evolve to be the long-haul aircraft it is today." He believes the A321XLR "is coming in very nicely to where the 757 left off. Maybe Boeing could rue the day they didn't decide to

Route proving for the A321XLR included a visit to Madrid, the home base of initial operator Iberia

Airbus



replace that like-for-like."

Strickland identified the A321XLR's advantages: "It's lower risk in two senses. One, you're not having to start offering a massive amount of seats to a market. You're not having to worry about filling a widebody because the capacity is much less. Two, that means much less fuel and with the greater efficiency of lighter weight components like carbonfibre composites.

"It also gives incredible flexibility. We've already seen how it will work with the LR with Aer Lingus. Aer Lingus can do a US flight, then, rather than sit waiting for its next transatlantic flight, it can do a shorter flight – say to Portugal, carrying leisure traffic. You get productivity out of the aircraft. You can move a lot of people at less capacity, at lower cost, and have flexibility in how to use the aircraft."

In this way, the A321XLR is an heir to the Boeing 757 as a versatile single-aisle narrowbody able to maintain a long-haul route for an airline at times of lower demand when it would be commercially unviable to use a larger-capacity aircraft

or else add capacity to existing routes where needed.

Tellingly, many current or former 757 operators have ordered A321XLRs, including Aer Lingus, Icelandair and the 'big three' US carriers: American, Delta and United. Icelandair is also planning to lease four A321LRs by summer 2025 as an interim step before its XLRs arrive at the end of the decade.

According to Airbus, the A321XLR presents possibilities for opening new services that were previously unviable: "Airlines will be able to operate a lower-cost single-aisle aircraft on longer and less heavily travelled routes – many of which can now only be served by larger, and less efficient widebody aircraft." The company notes that the A321XLR will have the range to fly city pairs such as London-Delhi, Miami-London, New York-Rome, Miami-Santiago, Hawaii-Houston, Tokyo-Sydney, Reykjavik-Dubai, and Auckland-Hawaii.

Analysts are more cautious about the XLR's potential as a gamechanger for

long-haul air travel. Richard Aboulafia, managing director of the AeroDynamic Advisory, told *Air International*: "The XLR is certainly interesting as the most capable single-aisle available. The broader A321neo family has been a tremendous success and is helping to transform route networks, particularly in the North Atlantic. But it offers a niche capability. The XLR offers just a bit more than the LR, with higher costs and other complications. It will certainly be worthwhile as a programme, but the other A321neo family members will really garner the bulk of the series' sales."

Strickland noted the challenge encountered by Norwegian when it operated 737s to the USA from Scandinavia, Ireland and Edinburgh until withdrawing from transatlantic long-haul in 2021 amid restructuring: "They found it was fine in the peak of summer, but given the seasonality profile of many of these markets, it was no good in winter."

Strickland said long-haul travel with a single aisle is "complicated", and





airlines must be selective. JetBlue, for instance, has started using A321LRs to London, Paris and Amsterdam: “They’re looking for markets where they can get the premium segment because they want to sell their Mint business class. They need markets where there’s enough traffic, which tends to be the bigger gateways.” While JetBlue has ordered A321XLRs, Strickland cautioned: “They will need to be careful about where they

put them. They’ve decided now to make Gatwick seasonal, which tells you that even Gatwick is harder than Heathrow regarding customer profile.”

Wizz Air announced in September 2024 that it intends to use its A321XLRs on a London/Gatwick-Jeddah route, catering for Haji and Umrah pilgrimage travel. “That could work,” Strickland said, “but that’s not the same as a leisure market deciding to go somewhere on

holiday and [having to] sit there for eight hours.”

Strickland noted: “People say ‘It’ll open up all these new routes’, but it doesn’t follow that it’ll work. You might be able to fly operationally, but are you going to get the passengers? You’ve got to use an aircraft efficiently. It doesn’t mean that because it can do something, it’s necessarily sensible to do it. It’s the size of the market.” **AI**

TOP:
Airbus has sought to maximise commonality between the A321XLR and other variants

FP Rodriguez/Airbus

RIGHT:
Airbus has secured more than 300 orders for the A321XLR since launching the variant in 2019

H Goussé/Airbus



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Noted for its similarity in appearance to the US F-22 Raptor, South Korea's KF-21 Boramae offers a low-cost alternative to the F-35 Lightning II.
Jack Richardson examines if the fighter is a viable alternative



Korea's cutting-edge step

With sixth-generation fighter programmes advancing worldwide and at the other end of the scale, increased focus on cheap, disposable Unmanned Aerial Vehicles (UAVs), the market for current-generation fighter aircraft has had less time in the spotlight. That has not deterred manufacturers, with Eurofighter claiming up to 200 Typhoons could be ordered in the years

ahead. Alongside traditional rivals such as Dassault's Rafale, Korea Aerospace Industries (KAI) is looking to take a share of this market with its Korean Fighter 21 (KF-21) Boramae (translating as 'hawk').

Professor Keith Hayward, a freelance consultant and writer, explains the process of developing a combat aircraft industry: "It used to be that the entry-level combat aircraft was the strike trainer, and that's where they first started out, and you can see a whole bunch of states that have built a strike trainer, a hawk-like aeroplane, but getting into fourth, four



The KF-21 took its maiden flight on July 19, 2002; note Meteor missiles were carried on each of the fuselage hardpoints with an internal weapons bay not currently utilised
KAI





and a half generation is a fairly complex and expensive business."

For South Korea, in this process, the KF-21 project was launched in 2001 by then-South Korean President Kim Dae-jung. Renderings depict a single or twin-seat, twin-engine, twin-tail aircraft which has a wingspan of 11.2m, a height of 4.7m and a length of 16.9m. With a payload of up to 17,000lb, a maximum take-off weight of 56,400lb and a top speed of 1,400mph, KAI describes the KF-21 as a '4.5 generation aircraft'.

KAI was selected to produce the aircraft in 2015, and the first KF-21 prototype was unveiled to the public on April 9, 2021. It commenced taxi trials on July 5, 2022, prior to making its maiden flight on July 19, 2022. During the ADEX 2023 expo in October of last year, the aircraft carried out a series of flying displays for the public. Another milestone followed on March 20, 2024, when the fifth of the sixth prototypes made contact

with a KC-30 Cygnus aerial refuelling tanker (the ROKAF designation for the Airbus Multi-role Tanker Transport).

The aircraft has several features inherent in fifth-generation aircraft, such as a shape that reduces its radar signature, an Active Electronically Scanned Array (AESA) radar and a Large Area Display (LAD) in the cockpit. However, it lacks other traits such as an internal weapons bay, instead having ten external hardpoints alongside an M61A2 Vulcan cannon. KAI therefore pitch it as a replacement for South Korea's F-4 Phantom II and F-5 Tiger fleets, the former having been retired earlier this year. In terms of capability, these characteristics place it above South Korea's F-16 but below the fifth-generation capabilities of the F-35.

Richard Aboulafia, Managing Director of Aerodynamic Advisory, told *Air International*: "Korea will always need a strong force of workhorse fighters, along



with a smaller number of door-kicker fifth-generation F-35s. For that large workforce, why not create something modern, local, and with an eye on exports? It's a smart plan."

This initial block one version, which South Korea ordered 20 of in June 2024 under a ₩1.96 trillion (Korean Republic Won) (\$1.41bn) contract, will be used for air superiority and delivered between late 2026 and August 2027. Another batch of 20 block one aircraft could be ordered next year after the aircraft's performance is evaluated. South Korea then intends to order a further 80 aircraft in block two configuration, an evolved multi-role aircraft, entering service between 2028 and 2032. As part of this roadmap, plans are already evolving for it to operate US weapons already in South Korea's inventory. These include the GBU-12 Paveway II, GBU-31/38 Joint Direct Attack Munition (JDAM), GBU-54/56 Laser JDAM and the GBU-39 Small Diameter Bomb.

To date, South Korea is the only export customer for the German/Spanish Taurus bunker-penetrating cruise missile.

With the weapon already integrated onto the F-15K Slam Eagle (a version of Boeing's F-15E Strike Eagle), South Korea could also fit it to the KF-21. Long-term plans call for the aircraft to deploy the locally developed Air Launched Cruise Missile and, eventually, hypersonic weapons. European missile house MBDA is offering several of its products for the KF-21. Images depict the aircraft armed with four Meteor Beyond Visual Range Air-to-Air Missiles on the hard points below the fuselage. KAI contracted MBDA to integrate the Meteor onto the aircraft in November 2019, and in November 2023, the two companies signed an agreement to explore the integration of the Advanced Short Range Air-to-Air Missile onto the aircraft.

Two of the other hard points are shown for ground attack, each carrying three Brimstone anti-tank missiles. Accordingly, the agreement signed in November 2023 covered the exploration of integrating the Brimstone and its turbo-jet-powered SPEAR Three derivative onto the KF-21.

Partnering up

Due to the high costs of producing combat aircraft, South Korea has attempted to share the KF-21 burden with

Indonesia. Hayward states: "What you're looking for is an extended production line. Historically, [with the] Tornado collaboration, it was more expensive than a single nation project, but the fact you had three nations' worth of procurement, guaranteed from the outset, turned it into a reasonable proposition. It's the adage: you spend a lot of money on development as long as you can make it back on production."

The participation in the programme by Indonesia was first announced in July 2010, with the country pledging to fund 20% of the overall costs with Indonesian company PT Dirgantara Indonesia (PTDI) contributing to the development of the aircraft in return requesting a prototype and pledges of shared production.

However, this partnership has not entirely proceeded according to plan in the years since.

In 2017, Indonesia reportedly failed to meet its funding obligations for the project, a situation that recurred in November 2023 when the deadline of the end of October passed. Subsequently, in August 2024, the two countries agreed to reduce Indonesia's contribution to the programme from ₩1.6 trillion to ₩600bn. Although Indonesia has already contributed ₩400bn to the project, the country's technology transfer and other benefits will be downgraded following the reduced funding. The exact details of this change have not yet been disclosed,

while the Defense Acquisition Program Administration (DAPA) and KAI will make up the funding shortfall. Aboulafia said that Indonesia's payment problems show the country as a 'weak partner', adding: "Their national aerospace industry capabilities are very limited, meaning they can only play a token role in KF-21 development and production."

Another way to do this could be to seek alternative partners and exports. In June 2024, the KF-21SA, tailorable to the needs of overseas operators, was unveiled. South Korea is already looking to gain a share of the international fighter aircraft market for the KF-21. KAI is pricing the aircraft at \$65m, two-thirds the price of a Typhoon or Rafale and cheaper again than the F-35A at \$82m. The aircraft is not only facing competition from incumbent Western manufacturers but also from other new entrants, such



CLOCKWISE FROM ABOVE:

The KF-21 will be able to attain speeds of Mach 1.8. It will not have an internal weapons bay; instead, it will carry four MBDA Meteor long-range beyond visual air-to-air missiles (BVRAAM) in semi-recessed fuselage stations. A maximum payload of 7.7 tonnes across weapons sensors and drop tanks can be carried on ten hardpoints

KAI

The KF-21 is rolled out on April 9, 2021

KAI

USAF F-16s and South Korean F-35As exercise together in November 2022. The KF-21 is designed for capabilities above the fourth-generation F-16 but below the fifth-generation F-35

Lockheed Martin



KF-21 Features and Specifications

Features

- AESA Radar & Advanced Avionics
- Advanced Precision Weapons
- 10 Weapon Hard Points
- High Maneuverability
- Enhanced Survivability
- Advanced Support Features
- High operational efficiency
- Single & Tandem Seat Aircraft

Specifications

Max. Thrust	44,000lb
Ferry Range	1,550nm
Max. Speed	1,400mph
Max. Payload	17,000lb
MTOW	56,400lb
Length	55.4ft (16.9m)
Width	36.7ft (11.2m)
Height	15.6ft (4.7m)

“Having designed the KF-21, the aircraft has passed significant milestones, catching the attention of industrial players and air forces worldwide”



as Turkish Aerospace Industries with its 'Kaan' fifth-generation fighter, which could also target the same market segment (cheaper than American types) as the KF-21, with Ukraine having reportedly expressed an interest.

In Aboulafia's view: "Korea has a home government that is realistic about technology partnerships with the West. Turkey does not. Turkey's dalliance with Russia greatly complicates everything. So does a lack of realism about what it will take to develop home-grown subsystems for the TF-X."

He added that other potential rivals, such as Sukhoi's Su-75 *Checkmate*, are undermined by this aircraft not being ordered by the Russian military and very few countries wanting a strategic relationship with Russia. China's FC-31 and J-20 designs face this problem because "no serious customer outside Pakistan wants a strategic relationship with China".

One market where KAI has already achieved success is Poland. Since Russia's invasion of Ukraine, Poland has embarked on a major military modernisation, including the FA-50 Fighting Eagle, a derivative of KAI's T-50 Golden Eagle family, which preceded the KF-21. When the two countries signed an agreement recognising airworthiness standards for military aircraft in January this year, suggestions have grown that Poland could co-operate with South Korea on the KF-21.

Another opportunity for KAI to export the KF-21 is closer to the aircraft's home market. The company has already successfully sold the F/A-50 Fighting Eagle to the Royal Malaysian Air Force under the F/A-50M designation. Even as the country's F/A-18 Hornet fleet is ageing, Malaysia could not proceed with its earlier Multi-Role Combat Aircraft programme.

As competitors such as the F/A-18E/F Super Hornet move towards the end of their production run, the KF-21 has emerged as an alternative alongside the Su-57 *Felon*. In September 2024, it was reported that KAI had offered the Philippines an additional 12 F/A-50s and ten KF-21s in the block one version, allowing the country to take advantage of the aircraft's capabilities as they grow. In July 2024, it was reported that Peru, an early operator of KAI's KT-1 trainer, could follow on with a purchase of the F/A-50 (locally producing some parts) and eventually join the KF-21 programme.

Perhaps most significantly, the wealthy Gulf nations of Saudi Arabia and the United Arab Emirates have been identified as possible partners in the KF-21 as the aircraft progresses from a 4.5 to a fifth- and potentially sixth-generation fighter, building on improving ties between these countries and South Korea.

Breaching the global market

Regarding the supply chain, KAI has sourced 65% of components from South Korea. Still, many other partners are familiar across the industry, such as the UK's Martin-Baker, which provides a Mk.18 ejector seat. Other well-known industry names involved in the programme include Curtiss-Wright Defense Solutions, which supplies the data-acquisition systems and terrain-following radar from Elbit Systems.

As part of efforts to reduce reliance on overseas suppliers, the KF-21 will field an AESA radar developed by Hanwha



Systems. According to Hayward, this is a key attribute for the aircraft to have appeal in the export market. He says it has undermined attempts by the Eurofighter Typhoon partners to gain market share for their product.

Having made 18 test flights aboard a Boeing 737 testbed from November 2022 to February 2023, the radar made its maiden flight on the third of six KF-21 prototypes on March 4, 2023. Initially, South Korea had hoped to acquire US AESA technology, but this was impossible due to export restrictions. Hanwha had assistance from Elbit Systems under a 2021 deal in producing its prototype. Progress has already been made in integrating this system with the aircraft's combat system because, in May 2024, another KF-21 prototype successfully used the radar to designate a UAV and destroy it using the

CLOCKWISE FROM TOP LEFT:
MBDA is offering several of its products for the KF-21, including the Brimstone anti-tank missile
MBDA

Other new entrants to the fighter aircraft market include TAI's Kaan, which unlike the KF-21, features as internal weapons bay
TAI

The Taurus missile has been fitted to South Korea's F-15K Slam Eagles and could be applied to the KF-21
MBDA

The KF-21 is categorised as 4.9-generation fighter due to its advanced technology and performance, which are closer to fifth-generation fighters compared to 4.5-generation fighters
KAI

Diehl Defence IRIS-T missile.

Hayward stressed the significance of an indigenous AESA radar, adding: "If they're offering an independent AESA radar that is a sign of some competence." However, he said engines are the main 'Achilles heel' for new fighter designs. For aircraft South Korea currently plans to order, the General Electric F414-GE-400 engine will be utilised, the same type that powers Boeing's F/A-18E/F Super Hornet and Saab's JAS39 Gripen family. This power plant will be manufactured under licence at a new factory Hanwha has established in Changwon, South Korea, building on the reported 10,000 aircraft engines the company has produced over the last 45 years.

At the 2024 Farnborough International Airshow, Hanwha unveiled a concept for an indigenous engine that could power KF-21s beyond Block Two and future UAVs. Whether an entirely homegrown engine or one co-developed with an existing manufacturer will provide a long-term propulsion solution will be decided by the end of November.

According to Hayward, the engine is probably one of "the toughest mechanical parts of the product" due to its complexity and need for reliability. The KF-21EX, which will utilise a non-American engine, was unveiled in June 2024, an advanced version of the aircraft beyond Block Two, which will have fifth-generation features, including an internal weapons bay and a new engine. The significance of not having the General Electric engine would be freedom from US arms restrictions.

However, Hayward added this path is not straightforward because the 'big three' of General Electric, Rolls-Royce, and Pratt & Whitney (plus Safran) have experience in the field going back 50 years, and it will take a long time for new entrants to gain comparable expertise.

Multi-mission?

As the KF-21 enters service, KAI has already set a roadmap for how the aircraft could evolve going forward. One proposal is the KF-21N, a navalised variant unveiled at the DX expo in September 2022. A mock-up showed key features for carrier-capable aircraft, including folding wing tips to enable below-deck storage with ski-jump and catapult launch options, depending on how South Korea's CVX aircraft carrier programme progresses. As the aircraft evolves from 4.5 generation towards the fifth and sixth, a broader set of missions is envisaged.

The KF-21EA (EA standing for 'Electronic Attack'), was unveiled in June 2024 and offers a second crew member to operate the relevant systems. This version will be operated like the US Navy's EA-18G Growler electronic warfare aircraft, utilising three electronic attack and two electronic intelligence devices and AARGM-ER anti-radiation missiles.

Going forward, a major part of air power is the growing focus on collaborative operations between manned and unmanned assets, often termed 'Manned-Unmanned Teaming' (MUT-T). To this end, KAI is positioning the KF-21 to utilise this technology with the unveiling at the

TOP RIGHT:

The final KF-21 prototype makes its maiden flight, this aircraft is a twin-seat variant

KAI

BELOW:

General Electric's F414 engine will power the KF-21 with the engine manufactured in South Korea. The F414 is a proven engine, but as an American design, it could undermine efforts to export the KF-21

General Electric





ADEX 2023 expo of its Next-Generation Air Combat System, where the backseat aircrew in the twin-seat KF-21 would be able to direct a group of unmanned vehicles operating alongside the fighter.

According to a scenario set out at the 2024 Singapore Airshow, a small Adaptable Aerial Platform UAV would conduct electronic attacks on an air defence system before a larger 'loyal wingman' attacks the system prior to the KF-21 launching stand-off munitions

against the primary target. Current plans are for the MUM-T to be operational in the 2040s-2050s, with technologies being tested on the F/A-50.

In the 25 years since its establishment, KAI has advanced from a partner producing parts for established models to licensed production of helicopters, while venturing into space systems and following the incremental approach of producing propeller and then jet-driven training aircraft. Having designed

the KF-21, the aircraft has passed significant milestones, catching the attention of industrial players and air forces worldwide, following in the path of other KAI aircraft, with the opportunity to become a contender in the market. However, like any new product looking to beat more established competitors, the type still faces the challenge of breaking away from restrictions such as relying on third parties for components and ultimately proving its operational worth. **AI**





A widespread consensus as to what sixth-generation air dominance systems of systems would consist of is splintering in the face of budgetary pressures, the serious escalation of the very near-term threat and the apparent failure of some technologies to deliver what was once promised.

Nowhere is this more apparent than in the evolving story of the USAF Next Generation Air Dominance programme.

Jon Lake attempts to untangle the various threads



Future Fighter

The ongoing evolution of sixth-generation air dominance



Real-world operations in the post-Cold War period demonstrated the Western 'way of war' effectiveness. The Western way used air power to win air dominance by smashing enemy air defences, then operated virtually unmolested to dismantle the adversary's military capabilities progressively. The two Gulf Wars in 1991 and 2003,

operations in the Balkans, and over Libya in 2011 all demonstrated the inadequacy of Soviet-supplied integrated air defence systems (IADS), which could be defeated by a combination of low-observable (stealthy) attack aircraft and bombers, long-range stand-off weapons and effective suppression of enemy air defences (SEAD). This did not go unnoticed in Russia, especially in China, and they went to work on denying the

ABOVE:

Lockheed Martin is already using AI for spacecraft monitoring and control, and the OEM will no doubt use lessons learned with this technology in the development of a sixth-generation fighter

MAIN IMAGE:

Increasingly, some are pushing for the F-35A to form the basis of the NGAD system of systems, operating with the same adjuncts and effectors. Others believe that such a solution would be entirely inadequate to meet the threat in the 2030s and beyond

Both images Lockheed Martin



West the opportunity to employ its preferred 'way of war'.

The answer they arrived at was based on an anti-access/area denial (A2/AD) strategy, coupled with a specifically targeted rearmament programme, emphasising long-range air defence capabilities. Anti-access is intended to prevent an opponent from entering a given operational area, while Area Denial aims to limit the opponent's freedom of action within that operational area.

The strategy relies on a complex network of systems whose combined effect is to 'push back' an enemy to a sufficient distance that it cannot operate effectively. The expansion of Chinese 'counter-air' forces, including fighters, AEW aircraft, surface-to-air, ballistic and hypersonic land

and surface attack missiles, airborne radars and air defence/air warfare ships, already represents a more widespread and more complex array of threats than any projected regional US force could effectively handle or even significantly negate.

Effective A2/AD does not necessarily require making a given volume of airspace 'impenetrable' even to stealthy attackers. If the enemy's aircraft can be pushed back to more distant bases and if the enemy 'enablers' (tankers, battle management aircraft, stand-off jammers, etc) can be excluded, then the enemy's tactical aircraft will be unable to operate effectively.

Air Vice-Marshal Jim Beck, who became the RAF's director of capability and programmes in April 2024 and a former

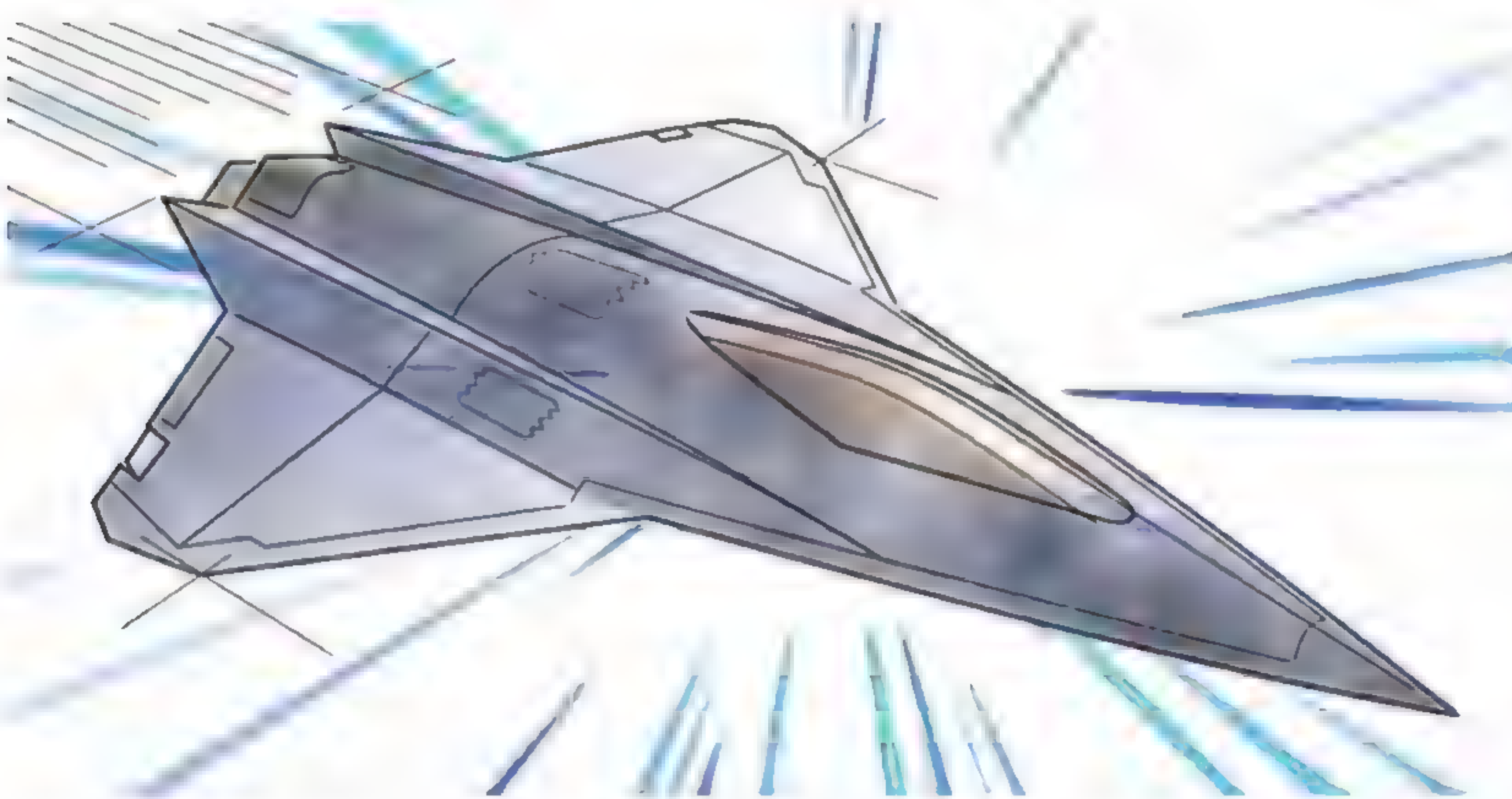
Lightning Force commander, outlined China and Russia's A2/AD capabilities, which he said, "push you away, to keep you out of the fight", and are "very, very difficult to overcome". He said the "ranges we're dealing with are 500 nautical miles today" and would "reach 1,000 nautical miles by 2030".

Birth of NGAD

When, in March 2014, the US Defense Advanced Research Project Agency (DARPA) concluded its Air Dominance Initiative study, looking at concepts that would provide air superiority for the US Air Force and Navy in the 2030s, it was clear the solution would be a 'system of systems' (sometimes described as a 'family of systems') offering a suite of capabilities and including a traditional, manned sixth-generation fighter at the heart of the system. The 'sixth-generation' label is usually associated with increased stealth, deep AI integration and machine learning, allowing complex collaboration with uncrewed platforms. The next-generation air dominance (NGAD) fighter also needed sufficient range for the Indo-Pacific (where, due to China's A2/AD capabilities, a fighter cannot readily rely on tankers to refuel, or at least not anywhere close to the combat area), necessitating a large internal fuel capacity. The aircraft would also require a significant and diverse internal weapons payload.

This large (and thus inevitably costly) manned fighter was to be augmented by a range of unmanned adjuncts and effectors that would provide combat mass and be able to 'stand in' further in contested airspace. Moreover, the affordable mass provided by unmanned collaborative combat aircraft (CCAs) would be available sooner than the NGAD core manned fighter and would operate alongside aircraft like the F-35A and F-15EX. CCAs promise to be a genuinely disruptive agent for the US Air Force, providing mass for a force structure that would otherwise risk being overmatched in the Indo-Pacific.

By the time DARPA concluded its Air Dominance Initiative study, the US Navy's F/A-XX programme was already under way and, confusingly, it had already used the same NGAD acronym as the USAF system of systems would soon adopt! NGAD was briefly conceived as a joint air force-navy programme, but the two services soon established separate offices, and the



ABOVE: Lockheed Martin revealed this unusual aircraft concept in a Skunk Works anniversary video. It was assumed by many to represent one of Lockheed's NGAD concepts, despite its apparent small size (judging by the enormous canopy) and single-engined configuration

Lockheed Martin

TOP: This aircraft, seen refuelling from a Lockheed Martin/Airbus LMXT tanker, is representative of what many expected NGAD to look like – a large, twin-engined tailless Delta optimised for Low Observability

Lockheed Martin



programmes diverged. Much less is known about the navy's programme, which has been deliberately delayed, freeing up funding for near-term priorities. It will be covered in a future article, but subsequently, this piece will concentrate on the USAF programme.

In the early days, the USAF's attention was primarily focused on the manned element of the system of systems to replace the Lockheed Martin F-22 Raptor. When Frank Kendall, then the US Department of Defense's acquisition chief, launched the Aerospace Innovation Initiative (AII) in 2015, it was narrowly aimed at developing technology demonstrators for the manned future fighter aircraft.

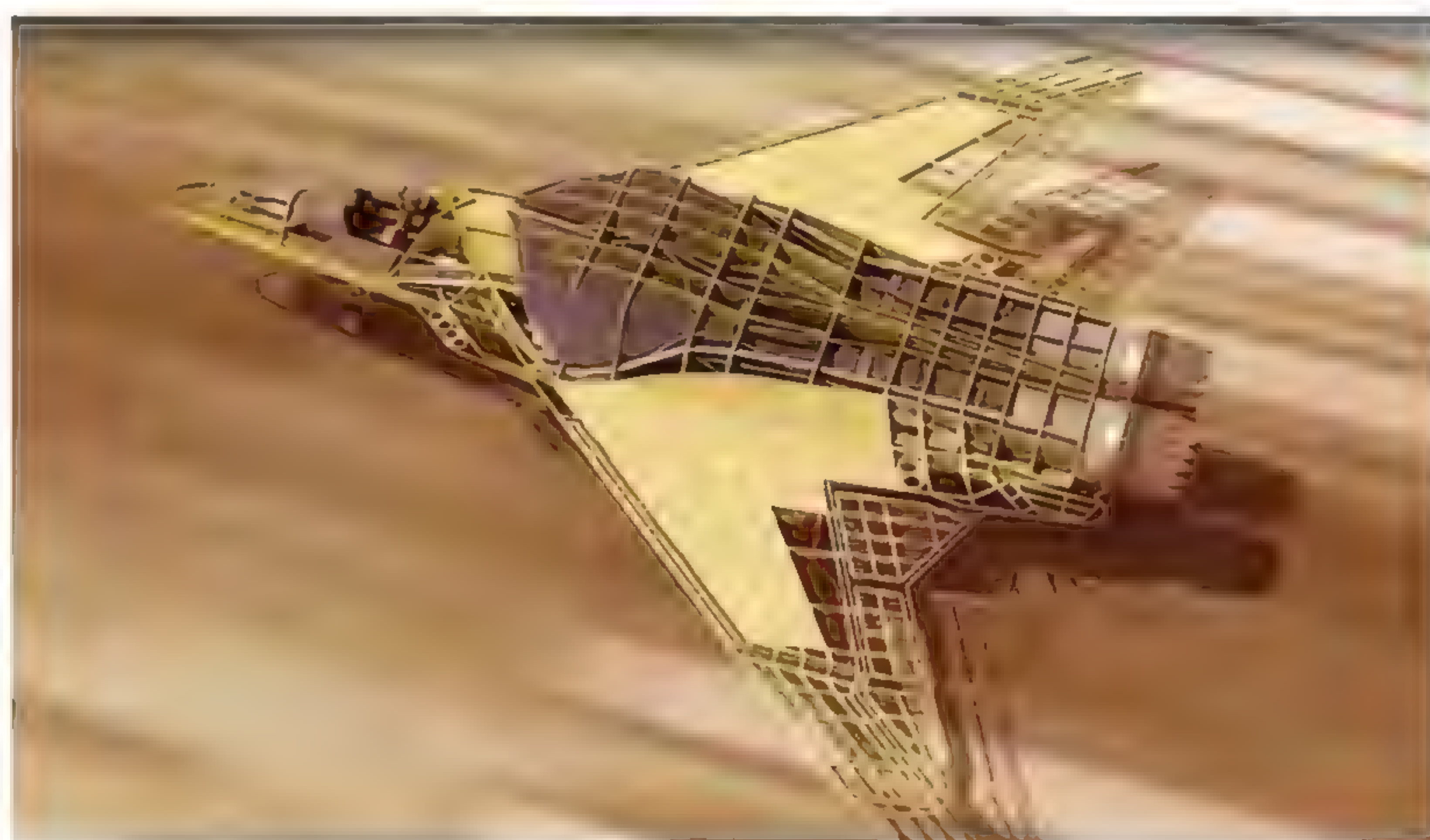
The USAF followed up on the DARPA studies with its own Air Superiority 2030 (AS 2030) flight plan in 2016. While this plan emphasised the need for a family of systems, it was again focused on the manned element, a fighter known as the Penetrating Counter-Air (PCA). The Congressional Budget Office estimated the unit cost of PCA to be US\$300m (\$375m in 2024 dollars). The AS 2030 flight plan evolved into the Next-Generation Air Dominance programme in 2018 when a greater emphasis on unmanned adjuncts began to be manifested.

The 'original' NGAD family of systems

Under the original concept, the NGAD core manned platform would be teamed with a variety of unmanned CCAs – ranging in cost and capability from 'exquisite' UCAVs through more attritable vehicles and then on to expendable 'one-way' effectors.

At the 'top end' of the cost/capability pyramid was the so-called 'Loyal Wingman',

which would be cheaper than a manned fighter but would offer comparable capability "in mission execution". The Loyal Wingman would largely operate autonomously, with minimal direction from the human pilot of the accompanying manned fighter. Their role would be to use their sensors for targeting, to use their electronic warfare capabilities to jam enemy defences and to carry their



ABOVE:

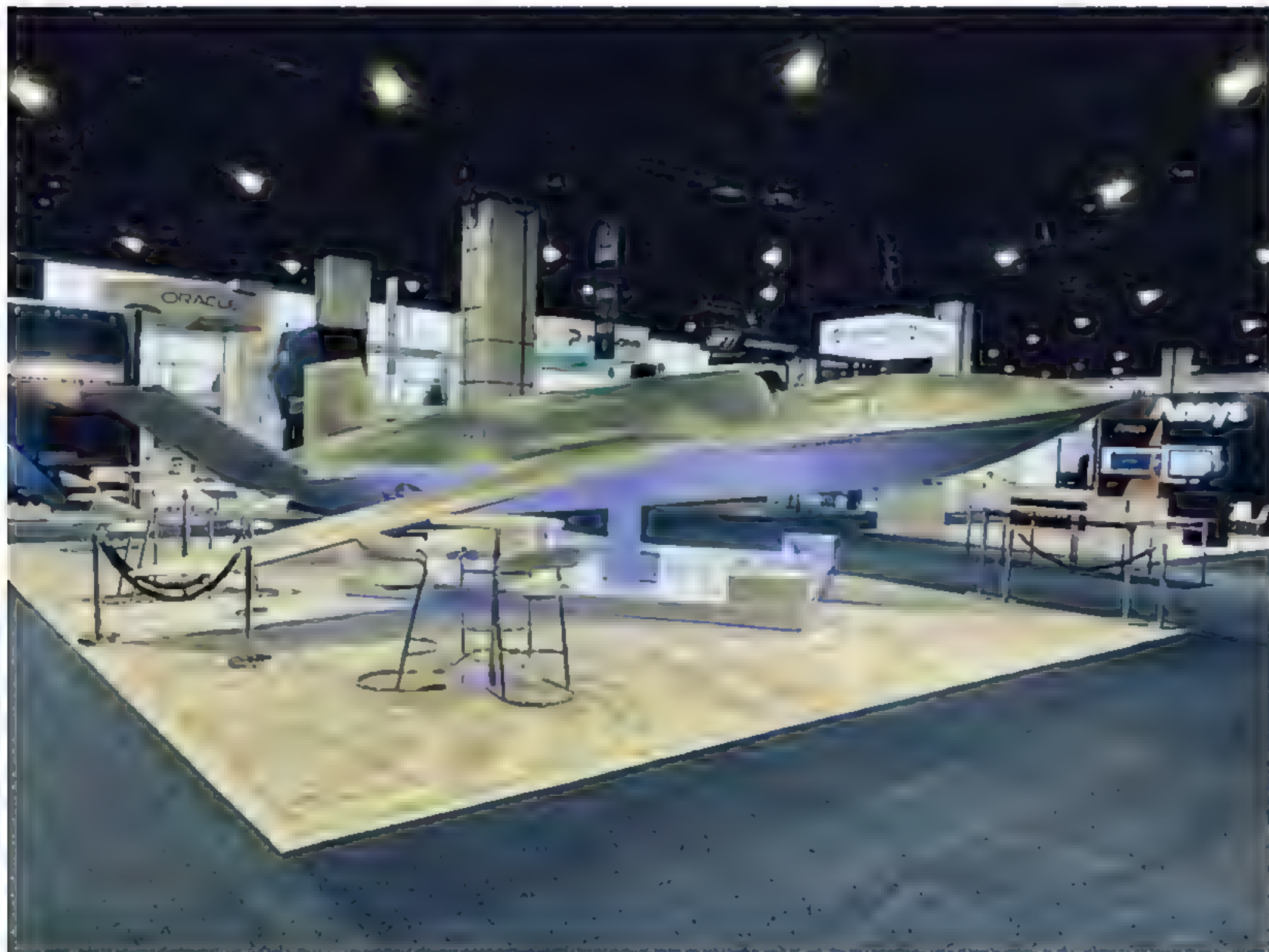
This presumed Boeing NGAD concept is again tailless but has an 'arrow wing' and conventional 'round' engine nozzles

Boeing

TOP:

Most CGIs illustrating NGAD have depicted a tailless Delta, often accompanied by CCAs flying in unrealistically close formation! In reality, the CCAs would be far ahead in the most contested airspace

Collins Aerospace



own weapons to attack enemy air and ground targets, probably flying ahead of the manned fighter and able to penetrate further into contested air space, accepting the possibility of higher loss rates as a result, but with a plan for them to return and be reused.

It rapidly became clear that these 'top tier' platforms would be more modest than once envisaged. The cost of providing fighter-like performance, range and broad-spectrum capabilities would be prohibitive, and today's high-end CCAs are, as a result, rather more modest, usually single-role (albeit re-configurable and rollable) and with more modest performance.

Frank Kendall, now the Secretary of the Air Force, has described CCAs as akin to remotely controlled versions of targeting pods, electronic warfare pods, or weapons carriers. They provide additional sensor coverage and greater 'effect' (kinetic and non-kinetic) while balancing affordability and capability.

This move by the USAF to a more modest type of CCA than the traditional Loyal Wingman echoes experiences elsewhere. In the UK, it was decided that such a platform (being actively pursued under the LANCA programme, with the Spirit Aero Mosquito) did not make financial or military sense "because the technology wasn't there to deliver them at a cost point that was efficient in the battle", AVM Jim Beck said. "It made more sense to go and buy manned assets at that point in time and to invest in the lower-cost ACPs."

The collaborative combat aircraft programme consists of two planned increments, each with different intended roles and capabilities. The programme has an overarching goal of delivering more than 1,000 CCAs cost effectively. This figure was arrived at based on the need for two CCAs for each of the 200 NGAD fighters and two for each of the 300 F-35As.

The aircraft being procured under 'Increment One' will primarily be for air-to-air operations. They will have sensors and targeting systems and may carry additional weapons to augment those carried by manned aircraft. The Increment One aircraft will likely use a modular approach to undertake different roles and tasks.

The 'Increment Two' CCAs will incorporate greater autonomy and low observation (stealth) and are intended to undertake or support electronic warfare and SEAD missions. They will demonstrate a 'resilient

THIS PAGE FROM ABOVE:

The General Atomics Increment One CCA contender is closely based on the GA-ASI XQ-67 Off-Board Sensing Station, already flying in prototype form
General Atomics

The GA-ASI XQ-67 Off-Board Sensing Station is already flying in prototype form and is a dedicated adjunct designed to take sensors further forward into the battlespace
US Air Force

The General Atomics Aeronautical Systems Inc. (GA-ASI) Gambit was developed, in part, to validate the 'genus/species' concept developed by AFRL as part of the Low-Cost Attributable Aircraft Platform Sharing (LCAAPS) programme and is a modular family of UCAVs based on a common core
General Atomics



sensing grid' and have expanded weapons options, maybe even multi-role aircraft.

Some critics suggest that the USAF is pursuing the worst of both worlds in its collaborative combat aircraft, with aircraft that are likely to be relatively high-cost while offering only modest capabilities.

NGAD core manned platform reimagined

While the apparent abandoning of the high-end Loyal Wingman marked a remarkable shift from the original NGAD vision, the core manned platform requirement changes have been even more significant. Mooted initially as what Kendall described as "essentially an F-22 replacement" and expected to have a unit cost equivalent to three (or "multiple") F-35As, senior US Department of the Air Force officials have been pushing for a much cheaper aircraft for some time.

On July 30, *The War Zone* reported that a USAF spokesperson had said: "We are pausing source selection of the next-generation air dominance platform as we reconsider the design based on changing threats and affordability."

In retrospect, the decision to delay NGAD source selection was unsurprising, as some felt that the air force had been facing an unpalatable choice. Prominent analyst Richard Aboulafia said that with Lockheed struggling to execute the F-35 programme

and Boeing mired in technical, production and supply chain problems, the USAF faced "the worst choice the air force ever could have been forced to make".

The NGAD programme had been expected to reach a down-select decision this summer. Still, signs that this might not happen began to emerge when the USAF's most senior civilian and uniformed leaders appeared to doubt the force's commitment to the programme.

In June, Kendall told *Aviation Week*: "There are a lot of things that we probably might not have contemplated a few years

ago. Obviously, the need for air dominance will not go away. But what mix of systems and how we do that is something we can take another look at."

In an interview with *Defence News* on June 26, Kendall elaborated on why he was taking another look at NGAD. "It's a very expensive platform," he said. "It's roughly three times the cost of an F-35 and we can only afford it in small numbers. Ideally, I'd like to get it down to less than an F-35, or at least in the ballpark of an F-35."

Kendall clarified that NGAD, including the manned fighter, remained a priority. ➔



ABOVE:

A close look at the new lightweight 'Built to Adapt' fighter unveiled by General Allvin at the Global Air and Space Chiefs Conference. Some think that this is the aircraft previously mooted by the former Chief of Staff, General Charles Q Brown

US Air Force

TOP:

Anduril's Increment One CCA contender is based on the company's Fury – designed initially for adversary/target duties

Lockheed Martin



During a fireside chat organised by the Air & Space Forces Association in mid-June, USAF Chief of Staff of the Air Force, General David W Allvin conspicuously failed to guarantee that NGAD would be insulated from expected cuts in the 2026 Fiscal Year budget, which Allvin predicted would be “very, very thin across the board”.

Secretary Kendall reiterated at a media roundtable held during the weekend of July 20/21: “We’re going to take a hard look at NGAD. But the family of systems, which includes a crewed platform and CCAs, weapon systems, communications and offboard support... and space [based assets], is still very much the concept we’re pursuing.”

Kendall further explained that “for any major programme, the key decision point is... when you commit to doing engineering, manufacturing and development... That’s when you really up the investment that

you’re making. Once you make that commitment, you should have a lot of confidence that you’ve got the right design, concept, requirements and programme structured for success. We’re at that point pretty much on NGAD right now.”

Lightweight NGAD?

However, an implied commitment to a manned sixth-generation aircraft was not and is not a commitment to an NGAD of the size, capability and cost of what had previously been under consideration. During his speech to the Global Air and Space Chiefs Conference, hosted by the Royal Aeronautical Society in London on July 17-18, Gen Allvin argued that air forces needed to move away from the philosophy of seeing ‘built to last’ as necessarily being a good thing. Built to last, he said, can easily become an ‘albatross’ – shackling an air force to past legacy platforms and

thinking. Instead, he suggested that a ‘built to adapt’ approach, in which the use of standard software across multiple platforms might allow hardware to be rapidly upgraded or even discarded – echoing the ‘Digital Century Series’ approach espoused by Will Roper, the former US Assistant Secretary of the Air Force for Acquisition, Technology and Logistics.

As Allvin said this, his presentation showed a new, single-engined, relatively small fighter concept.

It was still being determined whether such a lightweight fighter would replace or merely augment the larger manned platform previously associated with NGAD. The idea of fielding two distinct versions of the NGAD manned fighter was not new. Retired Gen James M Holmes, the former head of US Air Combat Command, suggested precisely this, with one fighter optimised for the long-range missions demanded in the Indo-Pacific region and the other better suited to the shorter ranges required in the European theatre.

There were suggestions that a new fighter might be better tailored to operating with CCAs. Kendall observed: “The CCA concept came along after the service had begun working to develop NGAD.” Others suggested that a crewed fighter designed to operate synergistically with CCAs might be smaller and cheaper than the leviathan that NGAD had become.

The development of stealthy tankers could enable smaller fighters with limited range to operate effectively in the Indo-Pacific by operating closer to denied air space, thereby removing the need for fighters themselves to have an extraordinary radius of action.

The underlying requirement for NGAD has not changed, and pretending that CCAs are capable or mature enough to do the job (in concert with a fourth/fifth-generation fighter mix, or with a small, cheap new fighter, or on their own) is, at best, foolish and, at worse, disingenuous. Nor will unproven ‘paper’ low-observable tankers allow F-35s to unlock China’s A2/AD envelope. The core NGAD manned platform is needed. Moreover, it needs to be a big, highly capable, highly sophisticated long-range platform and will necessarily cost far more than current tactical aircraft platforms. Only about 200 will ever be built, and none will ever be exported. It will, therefore, never enjoy significant economies of scale.



ABOVE:
Two MQ-28 Ghost Bats accompany a Boeing F-15EX. The MQ-28 (known initially as Boeing Airpower Teaming System (ATS)) is being used to evaluate the Loyal Wingman concept, with nine now on order by the RAAF
Boeing

TOP:
Many of the NGAD options now being considered will heavily rely on air-to-air refuelling (AAR). Many are unconvinced that even the advanced configurations being mooted for the NGAS (Next-Generation Aerial Refuelling System) tanker requirement will be survivable even at the edges of China’s A2/AD envelope
Jet Zero



that's what we're going to do, and we'll fight for the money to have it."

"Distinct differences" in design parameters, materials and fleet size drive the higher cost of an NGAD sixth-generation fighter compared with older aircraft built more simply and in higher numbers. To achieve a price close to that of an F-35 or F-15EX, the only option would be to remove critical mission systems, disaggregate capabilities into the CCAs and network them together. But this would make the NGAD less capable in its own right, more dependent on the CCAs and more reliant on datalinks while increasing the cost of the unmanned platforms themselves. Imposing such dependence imposes a more significant risk for the mission since the loss of the CCAs could render the manned aircraft impotent. **AI**

The US probably can't afford a \$300m NGAD fighter when the aircraft is required. The USAF prioritises the two legs of the nuclear triad for which it is responsible. So, the top priorities are the B-21A Raider bomber and the LGM-35A Sentinel (also known as the Ground-Based Strategic Deterrent or GBSD). Both are consuming a massive slice of the available budget. The cost of the Sentinel programme, in particular, has almost doubled to just under \$141bn.

At the Air & Space Forces Association's 2024 Air, Space and Cyber conference, Secretary Kendall confirmed that the USAF was re-evaluating what it wanted from the crewed aircraft at the heart of the NGAD system of systems and returned to the theme of price, reiterating what he had said in his June interview with *Defence News* about the relative costs of NGAD and the F-35.

"The F-35 kind of represents, to me, the upper bounds of what we'd like to pay for an individual [NGAD] aircraft for that mission," he said, pointing out that the F-15EX and F-35 were roughly in the same cost category. He added: "I'd like to go lower, though."

"We need a unit cost that's affordable in significant numbers, though. So that's part of the equation. And [the original] NGAD itself is still a possibility. It's one of the things we're looking at. But the numbers are multiples of an F-35, and we'd like to get down from that. But if that turns out to be the most cost-effective operational answer,



THIS PAGE FROM ABOVE:

Boeing's F/A-XX contender. The US Navy's next-generation air dominance programme ground to something of a halt sometime before the USAF NGAD programme did, but for much the same reasons – to allocate funding to nearer-term priorities *Boeing*

This Lockheed NGAS concept looks stealthy, but also rather small, implying relatively little fuel payload available to offload *Lockheed Martin*

NGAD has always been seen as being a system of systems, with a range of unmanned adjuncts and effectors. Lockheed's vision of 'distributed teaming' lacks a traditional 'exquisite' loyal wingman and is seen here with the F-35A at its heart *Lockheed Martin*

Mission focused

In an unstable world, air forces are upgrading their manned intelligence gathering platforms. **Glenn Sands** spoke with Jason Lambert, president of intelligence, surveillance and reconnaissance at L3Harris, about the use of bizjets in this role



For L3Harris, “business jet missionisation” is playing an ever more significant role for the company according to Jason Lambert, president of intelligence, surveillance and reconnaissance (ISR). This is reflected in the scale of the ISR area on which the company focuses within its

overall structure.

Lambert explained: “With L3Harris ISR, it is playing an ever more important role in what we do. We’re a \$3bn plus business in terms of annual revenue and, as a sector across L3Harris, we’re part of the integrated mission segment, with around 7,500 employees based across five major sites in Texas, Oklahoma and

Tennessee. At Texas and Oklahoma we operate three airfields where we do our missionised work. Essentially, the legacy of the missionised business jets came from the work that we were doing on the legacy programmes with the USAF.”

L3Harris has maintained a long partnership with the USAF and this work has proved to be the starting point to ➤



*“Our mission statement for my teams is
‘Together we make the world a safer place
by delivering for our customers’”*

Jason Lambert, president, ISR, L3Harris



put missionised equipment into existing bizjets. It's worth noting that L3Harris does not see itself as seeking to create a new aircraft from scratch, as Lambert pointed out: “Our business is about missionising an aircraft in the airborne domain. This work started with the legacy platforms such as the RC-135 Rivet Joint, which is a programme that is the world's leading ISR capability for the US and the UK. That's a joint partnership and a total fleet of 31 aircraft in eight different configurations.

“The work we do in this regard involves maintaining the fleet in theatre. So we support all the forward deployed operations from a sustainment perspective. We also take the aircraft back to our facilities in Greenville, Texas, on a periodic basis. They come back every four to five years for a total teardown and overhaul. When the aircraft leave, they essentially have the timing of a new aircraft and the world's leading hardware and software to do an ISR mission.

“The technology and work that we have accomplished in this business means we've been able to take and find opportunities to put into alternate business jet platforms over the last several years. This business is heating up and getting even stronger. L3Harris has become the world leader in missionised business jets. Many of the jets we work on have previously been in the corporate VIP role, where they flew groups of executives around the world, so the aircraft are getting a more important second life in terms of what they are now doing in the world.”

With contracts and deliveries of missioned business jets numbering more than 50 aircraft, L3Harris has worked with all the big five OEMs within the bizjet market, making the company “platform agnostic” according to Lambert: “We take a very mission-specific focus for our customers. Based on what their needs are, we can work with the OEM to be able to define the right platform

and the right level of integration work to meet that specific mission based on the performance parameters of the aircraft, primarily focusing on jets.”

The three primary OEMs that collaborate with L3Harris are Gulfstream, Bombardier and Dassault, although the company has worked with others in the past, such as Beechcraft with their King Air turboprops, along with other Airbus platforms: “Right now we are working a lot with Bombardier, Dassault and Gulfstream and selling mission sets that perform with these aircraft and support a variety of operations. So ISR is a priority, with collection and the electromagnetic spectrum used for intelligence gathering, national security and long-range targeting. Additionally, we have a number of electronic warfare [EW] programmes underway.”

One of the most significant recent EW programmes for the company has been delivering the first three of ten EA-37B Compass Call platforms for the





USAF, based on a Gulfstream G550, which Lambert regards as the world's leading electronic attack and jamming platform: "We also have an international customer – a NATO ally has requested two of them. The aircraft is a very special product in how it's structured, with the capability having previously been hosted on a C-130. We're taking technology and the mission gear from what might have been a legacy fleet platform and bring it over into a business jet, for which the benefits are pretty dramatic. Flying at higher altitudes, at a longer range, with increased time on station, these aircraft have a much lower sustainment cost than the legacy platforms they are replacing.

"We are working with an aircraft that has a traditionally has a higher availability – the time on station. Business jets inherently are going to have anywhere between 95% to 99% of availability to be ready for a mission. We have a global installed base and, for the most part, we are working with an OEM support structure that can

help with the supply chain and AOG turnaround. The commercial business model the jet companies use to support their VIP customers correlates really well to the military customer when there's an urgent need."

While the company has been focusing on EA and ensuring the USAF receives its new platform on time, Lambert pointed out that the Gulfstreams have not only been limited to these types of mission: "We have completed ISR work on Gulfstream platforms, as well as Bombardier, and we're starting to enter the airborne early warning and control (AEW&C). Traditionally, this type of programme has been completed on types such as the Boeing Wedgetail, which is based on the Boeing 737. We're competing now in a programme in the Republic of Korea, using the system with a Bombardier Global 6500 platform.

"We've recently gone through a two-aircraft programme with the US Army called ATHENA-R, during which we

ABOVE:

L3Harris is the platform integration prime on the USAF EA-37B Compass Call 'Cross Deck' aircraft. The next-generation systems evolves the air force's 40-year mission of employing EA capabilities to support US and coalition air, surface and special operations forces

All images via L3Harris

BELOW:

The original Compass Call fleet comprised C-130 aircraft, designated the EC-130H, when integrated with the EA mission system. The heavily deployed EC-130H has served in every major US contingency operation since the mid-1980s and, until recently, has been continuously deployed to support US Central Command operations in the Middle East. L3Harris' Waco facility provided the integration and depot-level maintenance services to the legacy Compass Call fleet since 2003 – first with integration of the EC-130H, and now with the migration of the mission system to the modified special missions, Gulfstream G550 business jet

PREVIOUS PAGES:

L3Harris is teamed with IAI/ELTA Systems and Korean Air to offer to offer South Korea the next generation of survivable and agile AEW&C aircraft for its air force





ABOVE:
One of the company's recent programmes saw a 'green' Bombardier Global business jet inducted into the modification centre at Waco. Less than six months later, the aircraft completed its first flight as a newly missionised US Army Airborne Reconnaissance and Electronic Warfare (ARES). The agile solution was produced to help modernise and enhance the army's ISR capabilities

TOP:
L3Harris worked with MAG Aerospace on the US Army's Theater Level High-Altitude Expeditionary Next Airborne ISR Radar (ATHENA-R) programme for rapid development of its future ISR requirements

developed the outer mould line shapes – on the Gulfstream 6500, this means the large side cheeks. We partnered with the OEM to develop these to hold the mission gear and equipment in the aircraft. We took the baseline fuselage and put it through a set of riggers to change the outer structure. After this it needs to go through a certification process, traditionally with the FAA or with EASA. This can also be completed with foreign militaries and US armed services who are keen to maintain platform certification. We have to go through the aerodynamics and characteristics of how the shape is going to perform inflight, link that all back

to the flight management system and flight controls."

In the case of the EA-37B that the USAF recently introduced into service, the side cheeks are where the electronic attack jamming equipment is located. In the AEWEC configuration that L3 is proposing for South Korea, the cheeks will hold an equipment suite tailored for this particular mission: "We're working with South Korea using a Bombardier aircraft which will have side cheeks similar to that on the Gulfstream 6500, partnering with IAI/ELTA, an Israeli company that will make the radar that's going to be used on this platform.

"It's an exciting time to be involved in the ISR, electronic attack and airborne early warning and control, but L3Harris has a further mission that requires supporting right now: maritime surveillance. Coastal patrol work efforts have increased in recent years and we have a programme running now with the Japanese Coast Guard, which operates a Dassault Falcon 2000. It's another mission set we can operate on the jet space."

With the amount of current and future work L3Harris is undertaking with the missionised business jet market, Lambert is ensuring that his teams remain focused on what they are providing with the finished platform, as each aircraft leaves the production line: "Our mission statement for my teams is 'Together we make the world a safer place by delivering



for our customers', so the people that come to work here know that they are making a contribution to national and global security."

As a company, L3Harris has long realised the value of experience when hiring veterans: "We have a significant number of ex-military folk, around 30%, that are coming from the USAF and Special Operations organisations, as well as some international military customers that come on to the team."

"What I like to say to the team, about the these jets, particularly the ones that you know were used previously in a VIP mission carrying around a group of executives somewhere, is they're getting an important second life in terms of what they're doing in the world."

So where is the demand for missionised business jets coming from? Lambert explained: "It's a couple of things. You're typically getting an aircraft that's fresh off the production line. In some cases you can take a user-modified aircraft and go through that transition, but the acquisition cost of the platform is the benefit. Typically, the performance of the aircraft is much higher. So if you think what a C-130 can do verses a Gulfstream G550 converted into an EA-37B. It's a better cost, it's a better sustainment model and its performance is significantly better."

"This gets the operator thinking about altitude, range, time in the area and simply being able to fly the mission."



Where is it taking place? Where is performance most needed? What's the standoff distance if the customer is intending to conduct intelligence gathering missions or collecting signal data? These missions can be conducted further away with a business jet than a traditional propeller aircraft. So these are big drivers behind the switch to business jet platforms. You get all this capability coupled with a better operating cost. From a flight hour perspective, the cost is quite favourable compared with traditional ISR platforms. Part of this is because of the sustainment model available and the aircraft availability for these

ABOVE:
The first ATHENA-R, based on the Bombardier Global 6500 conducts a test flight before receiving its final coat of paint. This view illustrates the numerous modifications made to the airframe, including the 29ft (8.8m) canoe housing mounted on the underside

TOP:
MAG's proven capabilities and extensive managing and executing large and complex turnkey ISR programmes in the world's most challenging operational environments enable the MAG/L3Harris partnership to provide the lowest-risk and best-performing solution for the ATHENA-R platform



platforms. In terms of modern business jets and what they are capable of, these aircraft offer our customers a good value proposition."

Lambert outlined the usual acquisition process for a missionised business jet: "If they're an international customer, there's a couple of different ways that we can provide a platform. Initially, we try to define the mission set. This is when we take the 'platform agnostic' approach. Instead of trying to sell an aircraft, we're trying to sell us, L3Harris, and support the customer in a solution to their mission they're looking to obtain. That depends on what they're looking to do on the platform, the geography of the country that they're operating within, the location of bases. We also establish the operating profile of how they will be using the aircraft. How do they want to perform the mission?"

"We then examine the platforms available and suggest the best fit. It's not always starting from scratch, because anytime we do non-recurring engineering and change the mould line shapes of an aircraft, there's a cost associated with it. We do take a look to see if there's something unique that we can put into play – that's what we are doing now in advancing the work in Korea, compared to, say, another international customer we have that's going to use the ISR capability on an existing jet with an outer mould line shape we already have. It's focusing on the best option for the customer.

"It's then a case of how we want to undertake the contracting and there's

a couple of way to do this. The first element, of course, is the aircraft. We can obtain an airframe straight off the production line – from Dassault, Gulfstream or Bombardier – and start from there. Or we can look at aftermarket availability, which, in many cases, customers are fine with."

The first EA-37B Compass Call platform recently delivered to the USAF was based on the now out-of-production G550, which was acquired by L3Harris from the VIP aftermarket network. A ready supply of the type is available in the second-hand sector under trade-in deals: "We can then set up a contract with the customer to do one of two things. Either do a transaction with the aircraft and the entire system together or do the deal in parts.

"We have certain customers that, based on the technology they're looking for, will require US government approval to do the mission set. And, of course, there's US export law, to which we have to adhere. In some cases the technology involved, in addition to the US exportability, will necessitate going through a foreign military sale channel, where the customer is actually transacting the mission system direct with the US government, but they can transact the jet with us. This is what's termed a hybrid business model, where we're doing work on a direct commercial sale of the aircraft and maybe modification of the jet, but the mission gear is coming from the US government through L3Harris. Another option is to do the entire transaction as

a direct commercial sale. An example of this is where some of the ISR technology or capability is exportable. In these cases we would liaise with the US government for approvals for the export licence, but the customer would only have to deal with L3Harris for the entire transaction."

With the extensive range of capabilities and platform configurations available when selecting a missionised business jet, is there a particular configuration that is the most challenging to produce? Lambert said: "The benefit of using a business jet is that we can do multi-mission. So if a customer wants to have an individual platform or a fleet of aircraft with a wider breadth of technology – not just be ISR or electronic attack or warfare – we could do these within a multimodal content, which is where these platforms get the most complex. It can be a function of system integration and also the amount of gear you utilise based on the size of the platform. The 'geography' in the aircraft and the available space is a driver of complexity.

"It also has to take into consideration the amount of change we have to do externally to the aircraft. An example of this is the side cheeks on the EA-37B, where we worked collaboratively with Gulfstream to go through the certification process and manage the aerodynamics for this particular customer requirement. We also have an ISR version where we're working internationally with Gulfstream, also on a G550 where we have done something similar. We've just finished



LEFT:
Rendering of a missionised Dassault Falcon 2000 platform

BOTTOM:
The multi-sensor test facility in Greenville, Texas. The capability provides the testing capability for electronic warfare, reconnaissance and communication systems, among other things

another ISR aircraft for a US Army programme, where we partnered with Bombardier Global 6500 to put a 29ft canoe fairing housing an airborne radar on the underside.”

This US Army programme is known as Army’s Theater Level High-Altitude Expeditionary Next Airborne ISR Radar (ATHENA-R), which developed from the

earlier ARES programme, and uses the 6500 to support long range precision targeting missions in the US Indo-Pacific Command area. The platform is designed to close the gap between the service’s medium- and high-altitude ISR aircraft. The ATHENA-R provides longer range, greater endurance, more capacity for bigger payloads and standoff ranges utilising leading-edge sensor technology. Lambert elaborated: “This aircraft carries one of the world’s most powerful airborne radars, of which there are only three in the world. These radars are built by one of our partner companies and, as with other platforms, we had to certify that the airframe would perform inflight in the manner we expected and within our parameters, based on having a new shape on the outside of the aircraft.”

With the rise in the use of UAVs and drones over the battlefield, both in an offensive and intelligence gathering role, is there still a need for manned ISR platforms? Lambert believes so: “The way we see it at L3Harris is that there is a need for both as complementary systems. We have technology for our business jet application, which we can take and produce in a smaller form and put into a pod. We have technology that came the RC-135 Rivet Joint, which we put into a missionised business jet and could miniaturise into smaller forms. However, there’s a trade-off between what you can do in an unmanned vehicle for ISR compared with the additional content you can have from actually executing and

running an aircraft.”

As for the future direction of ISR, Lambert said: “Threat levels are increasing and the state of the world has changed substantially over the last few years. Our ISR technology is now performing in theatre in Europe. We have seen significant growth in our counter-UAS offering. We turned around technology to do anti-UAV or counter-UAS operations for Ukraine very rapidly.”

This system now in operational service in Ukraine is known as VAMPIRE. It’s an indication of the collaborative spin-off technology that L3Harris is known for, taking systems utilised on larger ISR platforms and move them into different spaces: “So we coupled the technologies that we have within the ISR space with a sensor that we use with one of our sister companies and an L3Harris WESCAM. Picture an EO/IR sensor that can perform laser designation, coupled with software used for cross-queueing of targeting, linked to a shooter that fires PKWS rockets using an L3Harris proximity fuse and it’s become a very effective solution for Ukraine to counter the drones coming from Russia. We came up with this technology in around a six-month period, from the initial demonstration to fielding it. We’ve got a number of these VAMPIRE units in theatre now and performing every day, at a fraction of the price of what a traditional kinetic vehicle would cost to do the same.”

In a future issue of *Air International* L3Harris will discuss airborne ISR within the maritime environment. **AI**



In May 2024, Airbus unveiled the RACER, a \$217m tech demonstrator that succeeded the company's retired X3 concept aircraft. After just seven flights it reached 420km/h, exceeding its 407km/h objective. **Jon Lake** and **Glenn Sands** describe what may lie ahead



Racing ahead

Airbus Helicopters' Rapid and Cost-Effective Rotorcraft (RACER) demonstrator made its maiden flight on April 25, 2024, at the company's Marignane facility in France. The aircraft flew for about 30 minutes, allowing the flight test crew to check its overall behaviour. The RACER ➔



The RACER is a high-speed helicopter demonstrator that aims to leverage increased speed to deliver significant added value for a wide range of missions such as EMS, SAR and commercial transportation
All Images via Airbus Helicopters



is an experimental high-speed compound helicopter developed by Airbus as part of the European Research Clean Sky 2 project, pulling together the skills and know-how of 40 partners in 13 European countries. The programme is intended to improve the environmental and acoustic performance of helicopters.

The underlying philosophy behind RACER's design is simplicity. Tomasz Krynski, head of research and innovation at Airbus, stated at the time of its development: "When we speak about future products, it is important to develop things that are simple and robust. With RACER, we were guided by the search for a simple design, because this results in an intuitive way of piloting. It's safe and stable, and there is a lower cost in applying maintenance."

The RACER's aerodynamic configuration was publicly unveiled at the Paris Airshow in June 2017 and the 2,500hp Safran Aneto-1X engine was validated in the same year. In February 2018, the Aneto-1X engine was initially selected over the intended RTM322 because it was 25% more compact for the same power rating.

As the final design was coming together, the manufacturing of long-lead items, including the lateral driveshafts, began. The subsystem design was

completed in October 2018. As intended from the outset, Airbus was keen to involve as many partners as practical to support its European Clean Sky 2 project, and this saw the involvement of GE's Avio Aero in Italy to produce the lateral gearbox housings, GE Aviation Systems in the UK to construct the wing's titanium

cradle, INCAS/Romaero in Romania to build the hybrid metal and composite main fuselage structure and Aernnova in Spain to develop the tail section primary structure.

Final assembly was due to begin in mid-2020, with the RACER expected to make its maiden flight in the last quarter



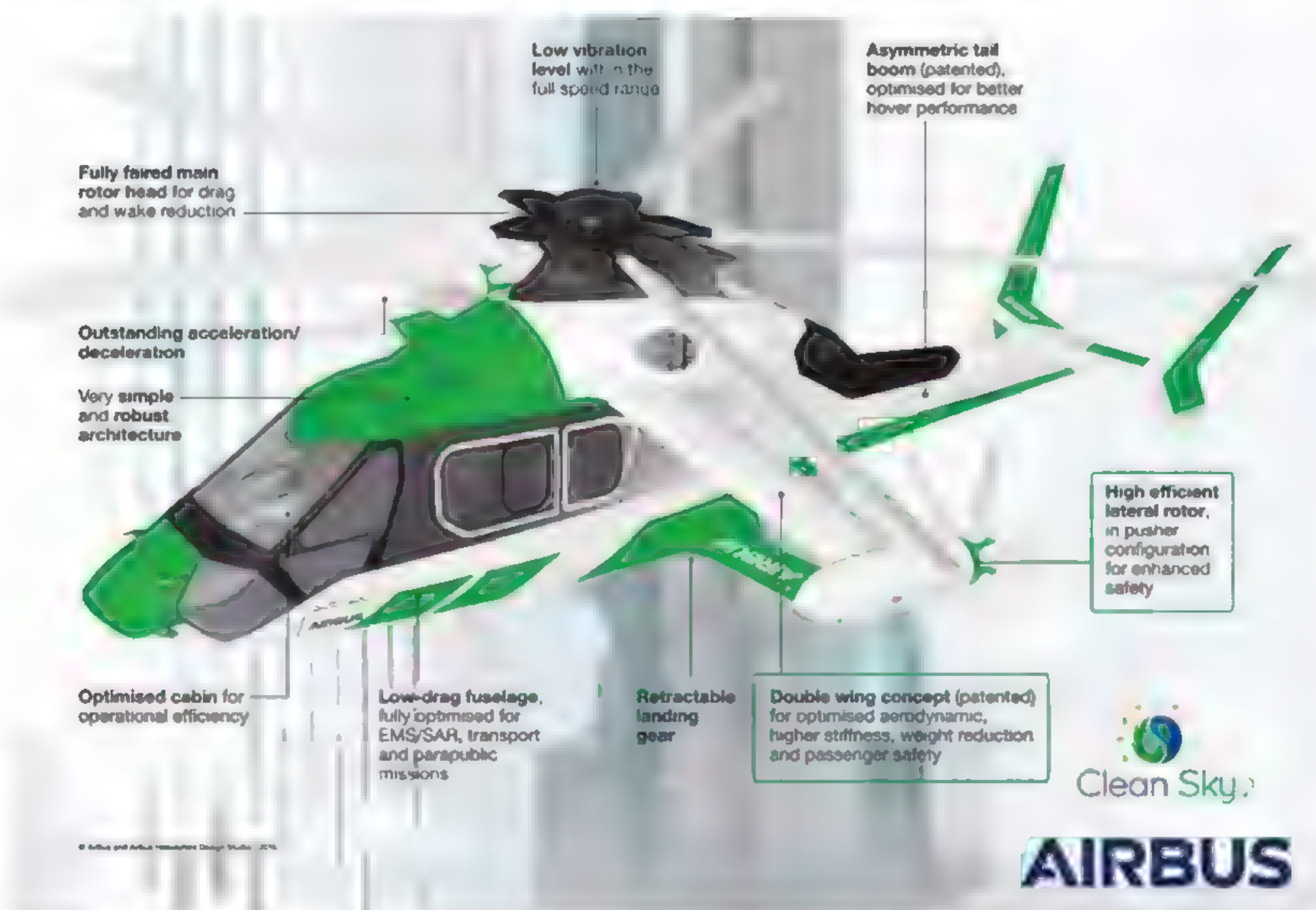
CLOCKWISE FROM TOP LEFT:

Built in absolute secrecy by Airbus Helicopters, the X3 was a technology demonstrator within the company for three years from September 2010. It reached a cruise speed of 220kts (410km/h), 50% faster than a conventional helicopter. It paved the way for the development of the RACER, which has a new cruise speed goal of 240kts (444km/h)

The only way to make a conventional helicopter fly faster and negate the speed restrictions placed upon it by the rotor blades is to add either a wing or a second rotor and propellers to increase the aircraft's speed

The RACER's two propellers are mounted on box wings joined at the tips by the propellers' bullet-shaped casing. The wings attain good cruise efficiency and have a small surface area above to minimise their interaction with the main rotor wake when the RACER is in the hover

The propellers are two lateral "pusher" types. In addition to providing thrust for high-speed cruise, they counteract the main rotor's torque effect, so replacing the role of a conventional tail rotor



of 2021. However, this did not occur due to the COVID-19 pandemic, which also impacted the RACER's supply chain. The pandemic's impact on the programme partners meant that the main gearbox did not arrive until March 2023, more than two years later than planned.

The RACER builds on the aerodynamic

configuration and compound architecture developed and proven on the Eurocopter X3 technology demonstrator. With a cruise speed of 220kts, 50% faster than a conventional helicopter, the X3 introduced a new aerodynamic configuration that has significant implications for future operations where speed means

saving lives, such as medical and SAR missions. It also paved the way for Airbus Helicopters' development of the RACER, which uses the same simple design and combines higher speed with fuel and cost savings.

The X3 attained an ultimate speed of 225kts in level flight and reached a speed of 264kts during a descent a few days before. The X3 configuration utilised a pair of RTM322 turboshaft engines, which powered a five-blade main rotor and two propellers on short-span fixed wings.

RACER aims to take the compound formula closer to an operational configuration, aiming for the best trade-off between speed, cost-efficiency and mission performance. The aircraft features a low-weight, low-maintenance hybrid metallic-composite airframe and a rear fuselage with an asymmetric cross-section designed to optimise hover performance without affecting forward flight efficiency and cruising speeds. The lateral pusher propellers on the RACER generate the thrust, but are isolated from the rear-seated passengers by the box-wing structure, adding to the overall lift generated when cruising. These engineering introductions allow the main rotor to be slowed down by up to 15%, preventing the blades from exceeding





ABOVE:
The asymmetric tail boom benefits from the interaction from the main rotor wake to provide a significant contribution to the anti-torque function on RACER

BOTTOM:
"The aim of the RACER is not to go as fast as possible, but to offer enhanced operational capabilities at the right price for missions where speed can really be an asset," says Julien Guitton

the speed of sound, which reduces the performance of a helicopter. An additional benefit of this is an overall reduction in the noise of the aircraft, which may well prove a key factor as testing shifts towards urban areas. Further weight saving comes in the form of a lower-weight, high-voltage direct-current electric generator. The upgrades introduced throughout the RACER mean that its fuel consumption is reduced by 15-20% at 180kts compared to a conventional helicopter flying at 130kts, which offers a 25% reduction in costs over a given distance.

The addition of a hybrid-electrical eco-mode system, developed along with Safran Helicopter Engines, allows one of the two Aneto-1X engines to be 'paused' during cruising flight, cutting fuel consumption and reducing CO2 emissions. Julien Guitton, who heads the RACER programme for Airbus, stated: "The eco-mode system, developed with the support of the DGAC (French Civil Aviation Authority) and several other partners, plays an essential

role in delivering the performance we expect. It involves putting one of the two engines on stand-by during cruise flight, with the ability to restart it almost instantaneously if necessary. The aircraft flies slightly slower than it would with both engines running, but it's still faster than a conventional helicopter. Above all, it saves 20% in fuel consumption." It also reduces the RACER's acoustic footprint, a driving force behind the Clean Sky 2 project.

RACER intends to demonstrate the advantages of high speed for a wide range of missions. This capability was shown on June 21, less than two months after its first flight; when it exceeded its level speed objective of 407km/h by reaching 420km/h in its initial configuration. Almost all of the flight envelope has been opened in just seven flights and about nine hours of testing.

Bruno Even, CEO of Airbus Helicopters, said: "This achievement in such a short space of time is really a testimony to the hard work of our partners to bring all of this innovation to flight. On top of its performance, the aircraft's aerodynamic behaviour and stability are promising. We are all looking forward to the next phase of flight testing, especially the eco-mode, which will enable us to shut down one engine in forward flight, thus reducing fuel consumption and lowering the CO2 emissions."

The flight test crew consisted of chief flight test pilot Hervé Jammayrac and flight test engineers Dominique Fournie and Christophe Skorlic. Airbus is currently focusing on the next phase of the two-year flight testing plan, which will focus on single-engine operations and finalise the flight envelope. **AI**



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Wrong place, wrong time

Runway incursions are a constant threat to the safety of aircraft and airport ground staff. **Alex Preston** looks at the efforts of all stakeholders to mitigate the consequences of this phenomenon





As air traffic operations increase, the risk of runway incursions is also likely to increase unless new safety solutions are implemented
Tom Fisk via Pexels.com

In early September, a Delta Airbus A350 bound for Tokyo-Haneda, Japan, taxiing out at Atlanta's Hartsfield-Jackson International Airport, US, made contact with the tail of a Bombardier CRJ-900 operated by Endeavor Air, a regional subsidiary of Delta, destined for Lafayette, Louisiana, on an adjacent taxiway, resulting in damage to the tail of the regional jet, and the wing of the A350. Luckily, no passenger or crew member injuries were reported, and operations continued as usual at the Atlanta airport.

Delta's TechOps teams have relocated the aircraft to maintenance hangars for evaluation.

There were 221 customers on the A350 and 56 customers on the CRJ-900. At the time of writing, Delta confirmed that it was co-operating with the National Transportation Safety Board (NTSB) and other authorities on this incident.

As the NTSB remarks, the runway environment is a far more limited area, often with a steady stream of aircraft taking off and landing on intersecting

runways, sometimes in poor weather and with limited visibility. These conditions put aircraft at an increased risk for ground collisions and runway incursions.

Safety breaches

The UK's Civil Aviation Authority (CAA) defines runway incursions as the incorrect presence of an aircraft, vehicle, or person on a runway. "The use of a runway involves aircraft coming into much closer proximity to one another than during normal flight. Hence, the





risk of two aircraft colliding prompts many organisations to consider as a priority, reducing the number of runway incursions."

Under the Federal Aviation Authority (FAA), there are four categories of runway incursions:

- **Category A is a serious incident in which a collision was narrowly avoided.**
- **Category B is an incident in which separation decreases, and there is a significant potential for collision, which may result in a time-critical corrective/evasive response to avoid a collision.**
- **Category C is an incident characterised by ample time and/or distance to avoid a collision.**
- **Category D is an incident that meets the definition of runway incursion, such as the incorrect presence of a single**

vehicle/person/aircraft on the protected area of a surface designated for the landing and take-off of aircraft but with no immediate safety consequences.

Operational incidents, pilot deviations, and vehicle/pedestrian deviations are the cause of incursions. As Thea Feyereisen, Senior Fellow at Honeywell Aerospace Technologies, observes, runway incursions are most frequently caused by human error. This can be an air traffic controller or pilot error. Common factors include situational awareness problems, communication breakdowns, confusion, and distraction.

"Typical events include the pilot being cleared for take-off while another aircraft(s) is on the runway. Another common event is when an aircraft is cleared for landing, but another aircraft

still occupies the runway. The third type is incursions related to simultaneous operations at airports with intersecting runways," she explains.

For example, in June, the NTSB issued a preliminary report on an April 17, close call at New York's John F. Kennedy International Airport, where the flight crew of a Swiss Air Airbus A330 rejected an attempted take-off at New York's Kennedy Airport after sighting traffic on the runway. Shortly after one air traffic controller cleared the Swiss Air flight for take-off on Runway 4L, another controller cleared four jetliners to cross the same runway. No one was injured in the incident.

In a separate investigation of a runway incursion at JFK last year, investigators found that airport surveillance detection equipment, model X, or ASDE-X, alerted

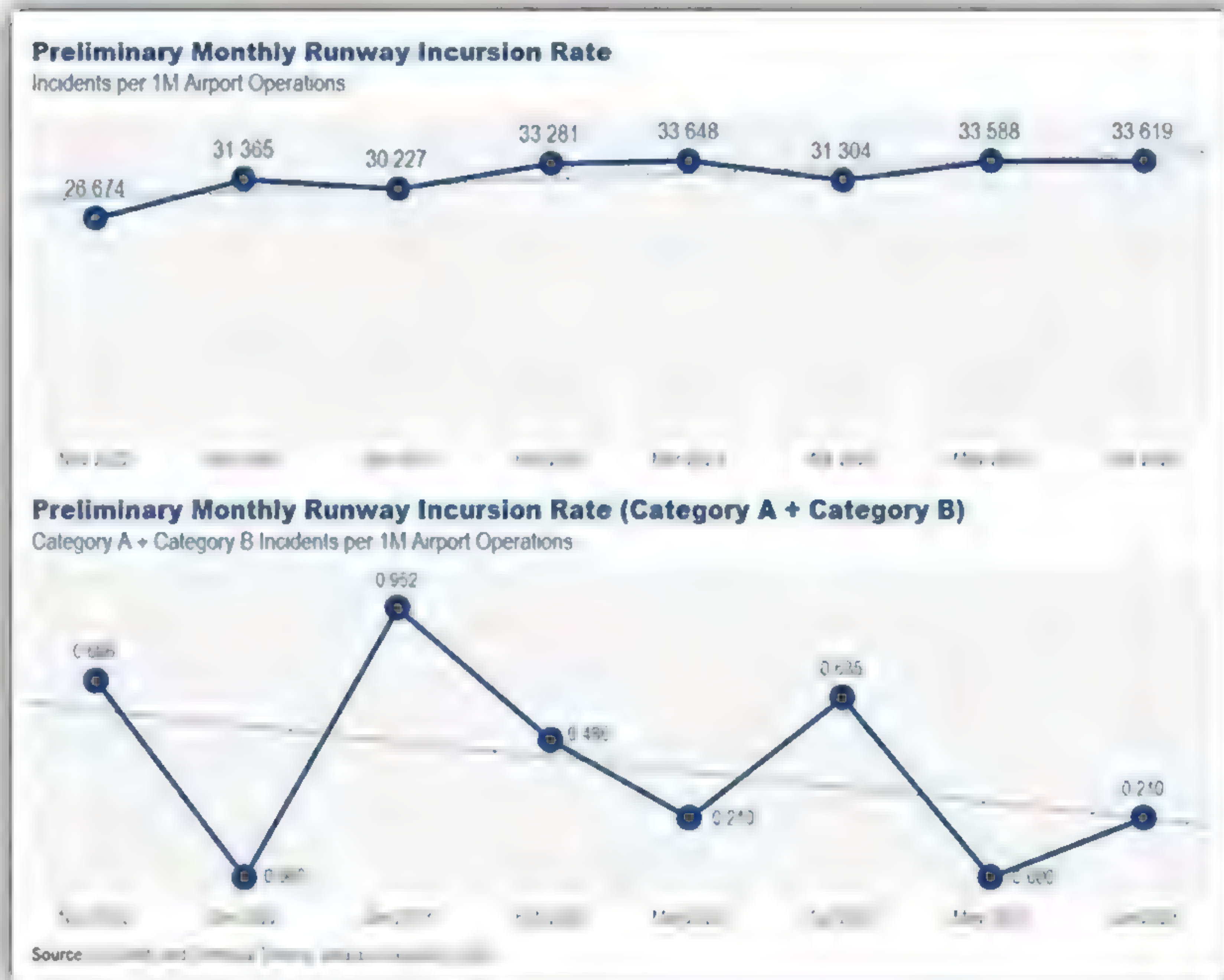


controllers of a potential collision. That same system did not issue an alert during the April 17 incursion because the Swiss Air flight never reached the thresholds of both acceleration and velocity that would indicate to the system that the jetliner was in a “departure state”.

According to the FAA: “We have seen a recent drop in serious runway incidents despite such incidences. In the first seven months of 2024, the rate of serious runway incursions (Category A and B) decreased by 74% from the same period in 2023, from 0.47 per one million airport operations to 0.12 per one million operations,” the agency says.

“Even one accident is one too many,” states Feyereisen. “The deadliest accident in aviation history occurred on the Spanish island of Tenerife when two B747s collided, and 335 people died. Earlier this year, we saw a fireball on the runway when an A350 crashed into a Dash-8 in Tokyo – fortunately, no one died in the A350, but five of the six people in the Dash-8 died in the crash. Over the last couple of years, we have seen a notable uptake in more serious close calls. They are getting closer and closer, with mere seconds and metres from life and death. We believe this is an area of concern for aviation safety, and the NTSB agrees, with a re-issuance of a recommendation for aircraft to be equipped with direct cockpit alerting to help reduce the likelihood of runway incursions,” she says.

Speaking at the NTSB Roundtable: State of Runway Incursions: A Path Forward, in May 2023, Jennifer Homendy, Chair of the NTSB, remarked: “If we want to upgrade existing technologies to prevent runway incursions, implement new technologies, invest in projects to reconfigure or construct new taxiways, install new lighting, modernise systems so that we are better able to use data in decision making and build upon an



already highly skilled workforce... that takes resources. That’s an investment in safety and in service.”

Safety as a North Star

With safety as its first priority, the FAA, in collaboration with the aviation community, is pursuing a goal of zero serious close calls.

Following the release of the National Airspace System Safety Review team report in December 2023, the FAA took immediate action. It has already provided additional support to colleges and universities in the Air Traffic-Collegiate Training Initiative (AT-CTI) Program. The FAA will work with AT-CTI programs to ensure that graduates from these programs have the necessary skills to begin on-the-job training at a facility. These graduates must still pass the Air Traffic Skills Assessment (ATSA) exam and meet medical and security requirements. Previously, these graduates were required to attend the FAA Air Traffic Controller Academy prior to being assigned to a facility.

Additionally, it has announced a year-round hiring track for experienced controllers from the military and private industry. It has pledged to keep filling every seat at the FAA Academy and increase classroom capacity beyond current limits.

It will also finish deploying tower simulator systems in 95 facilities by December 2025. The first system was installed in Austin in January 2024. Finally, it is committed to strengthening its own safety culture, providing reports from the Air Traffic Safety Oversight Service to the FAA Administrator and Aviation Safety Associate Administrator.

In August 2024, aircraft operators,

CLOCKWISE FROM ABOVE:

While US data shows progress is being made, one runway incursion is one too many
FAA

SURF-A uses GPS data, Automatic Dependent Surveillance-Broadcast (ADS-B) equipment and advanced analytics to pinpoint the exact location of traffic hazards on or near the runway and alert you if you are on a collision course
Honeywell

Transmissometer technology provides today's best visibility measurement accuracy for Runway Visual Range (RVR), and Vaisala's LT31 is the most trusted and frequently used transmissometer the world over
Vaisala

Launching in 2025, pending FAA approval, SURF-A is one of the first cockpit alerting software solutions to provide pilots with direct aural and visual alerts of potential runway hazards
Honeywell



“If we want to upgrade existing technologies to prevent runway incursions, implement new technologies, invest in projects to reconfigure or construct new taxiways”

Jennifer Homendy,
Chair of the NTSB

air navigation service providers, airports and regulators, a total of more than 200 aviation experts from 80 organisations around the world, took a collaborative approach to runway incursions, working together to develop the Global Action Plan for the Prevention of Runway Incursions (GAPPRI).

One high-level finding and conclusion from the report is the degraded runway status awareness issue. According to the report, “more than one-third of high-risk runway incursions could have been averted through better situational awareness technologies that assist air traffic controllers in detecting potential runway conflicts. Taxiway and runway stop-bars or similar functional barriers can significantly strengthen runway status awareness for pilots. Among the foremost risk scenarios for runway incursions are instances in which air traffic controllers clear pilots to land or depart on an occupied runway, pilots fail to hold short of a runway as instructed, or vehicles enter a runway without clearance. A systematic approach to addressing runway incursion scenarios and potential runway collision scenarios through risk and resilience management is likely to reduce or eliminate serious runway incursions.”

Low visibility and adverse weather conditions can impact situational awareness, increasing the risk of an incursion

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As a response, the report recommended the Integration of advanced technologies. The deployment of cutting-edge technological systems capable of providing real-time awareness of aircraft and vehicle positions, navigation route assistance, detection of deviations, and timely alerts for potential runway incursions and collisions is strongly recommended. These systems should be equipped to offer multiple layers of systemic barriers and in-depth defences. Immediate alerts for air traffic controllers, pilots and manoeuvring area vehicle drivers in the event of a potential collision or unauthorised runway entry are vital components.

Stakeholder solutions

As part of the Single European Sky Air Traffic Management Research program with program partners Airbus, Dassault and Eurocontrol, Honeywell has developed SURF-IA.

Feyereisen explains that Honeywell will introduce two different runway incursion technology solutions into the market over the next couple of years: SURF-A (Surface Alert) and SURF-IA. Neither is yet certified. SURF-A provides an aural and text alert of a potential runway collision.

SURF-IA provides the pilot with the same aural and text alert but also includes graphical encoding of the traffic on a traffic display with an airport moving map. "Few airliners today are equipped with an integrated airport moving map or display of surface traffic, so SURF-IA would be quite expensive to retrofit," she admits, but "SURF-A is a simple, impactful, and affordable offering for aircraft that are already flying."

Feyereisen says that SURF-IA is targeted most for new aircraft or "what we call forward fit." With the new integrated large format displays with airport moving maps and display of surface traffic, such aircraft will be provided with a solution that includes aural alerts, along with the graphical display to provide even more situation awareness with the colour coding of the threat traffic.

"SURF-A and SURF-IA will provide an ever-vigilant third set of eyes in the cockpit to alert pilots of a potential runway collision. Pilots are our last line of defence against runway incursions. We can provide them with aural and visual alerts in the cockpit to help reduce the chance of a runway collision – a growing threat to our global aviation ecosystem. While tools for ATC, improved

training, and improved procedures are all important safety layers to reduce the likelihood of runway incursion, SURF-A technology – directly supporting the pilots in real-time – is the most important and effective mitigation," Feyereisen adds.

SURF-A will improve safety by giving pilots real-time aural and visual alerts when they are on a trajectory to collide with an aircraft or ground vehicle within 30 seconds. It uses GPS data, automatic dependent surveillance-broadcast (ADS-B) equipment and advanced analytics to pinpoint the exact location of traffic hazards.

Honeywell also has SmartX, a solution that increases situational awareness on the ground with text and optional aural alerts of runway position, such as "Approaching Runway 4L". If a pilot is lost in low visibility or gets distracted and knows they were cleared across Runway 31L, but hears a different alert, earlier detection may be provided and the risk of a runway incursion reduced.

Smart X includes the Runway Awareness and Advisory System (RAAS) and the SmartRunway and SmartLanding software, which were introduced 15 years ago and have subsequently been installed on about 5,000 commercial aircraft.

Eco-friendly

Environmental factors also contribute to runway incursions. As Kari Luukkonen, Product Line Manager, Airport Weather Systems at Vaisala, explains, these include poor weather conditions, such as fog, heavy rain, snow, and low visibility, which can obscure runway markings and signs, making it difficult for pilots and ground vehicles to navigate safely. He also identifies runway contamination whereby ice, snow, or standing water on the runway can cause aircraft to skid or veer off course. Another factor is lighting conditions, with insufficient or malfunctioning runway lighting impairing visibility, especially during night operations or in adverse weather.

Typical events include aircraft or vehicles mistakenly entering an active runway due to these visibility issues, leading to potential collisions or near-misses.

"More frequent and severe weather events due to climate change can exacerbate visibility and runway condition issues. Rapidly changing weather conditions



The UK's NATS is diligent in allocating event types and causal factors to all reported incidents, ensuring it can deploy safety improvements based on recent trends as well as relevant international events

NATS

are likely to increase due to climate change, due to which low visibility and heavy precipitation events can occur more regularly,” says Luukkonen.

“Vaisala takes runway incursions seriously because they pose significant safety risks. Accurate and reliable visibility information is crucial for safe runway operations. Vaisala’s solutions, such as Runway Visual Range (RVR) systems, provide precise visibility data to help pilots and air traffic controllers make informed decisions,” he adds.

The 127 recommendations proposed by the GAPPRI include enhanced aerodrome visual aids. Enhancements to runway and taxiway signs, markings, and lights, particularly in adverse weather conditions, are essential for increased visibility and safe navigation. Additional signage at critical intersections and using stop bars or other lighting systems (e.g. autonomous runway incursion warning systems) are also recommended.

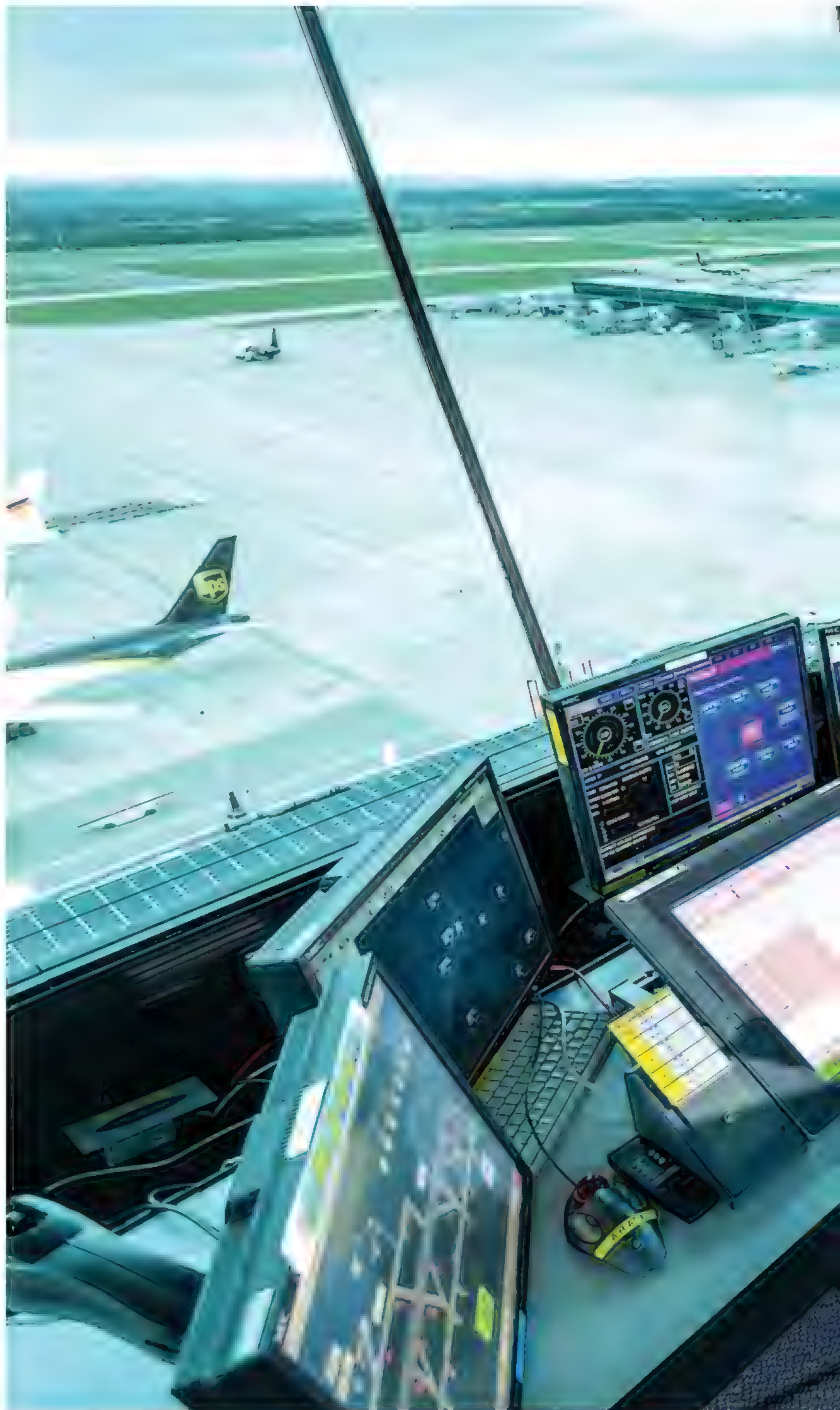
Vaisala offers several runway management solutions to prevent runway incursions. Its Runway Visual Range (RVR) System leverages cutting-edge technology, such as the LT31 Transmissometer and the Vaisala Forward Scatter Sensor, FD70, to provide accurate visibility measurements, crucial for safe take-off and landing operations.

In 2021, the Finnish company will conclude a five-year contract to deliver and install 80 RVR systems and subsystems to replace ageing systems. Low-visibility weather conditions most impact RVR, but ambient light levels and runway light settings also significantly impact it.

Another solution is the company’s Airport Weather Observation System (AWOS), an advanced weather monitoring system that helps predict and manage adverse weather conditions that could affect runway safety.

Additionally, says Luukkonen, wind shear—a sudden change in wind speed and/or direction—is an invisible threat that can lead to difficulties on take-off and landing. As he explains, the company’s AviMet Windshear Alert System leverages a combination of the latest wind lidar, weather radar, and anemometer technology to identify and provide timely alerts to ATC and pilots.

Finally, Vaisala’s RWIS (runway weather information system) provides real-time



“While there is already a strong safety net around runway incursions, it is accepted that the existing global safety system could be tightened”



weather data from in-pavement sensors, subsurface probes, and atmospheric sensors that can help reduce runway incursions by allowing airports to manage surface conditions proactively. These systems detect temperature changes, predict ice formation, and assess atmospheric factors, helping airport teams pre-emptively treat runways. Advanced forecasting software also integrates these insights, enabling accurate decisions to prevent hazardous conditions during winter weather. This results in more efficient runway management, reducing the risk of accidents caused by snow and ice.

"The cost of implementing these solutions can vary," admits Luukkonen. "However, airports and airlines are considered attractive investments due to their significant safety and operational benefits. Reducing runway incursions can prevent accidents and improve overall airport efficiency, protecting lives and providing long-term savings."

Taking action

In August 2023, the FAA announced it had awarded more than US\$121 million to airports across the country to reduce the risk of runway incursions, just months after an initial \$100 million to 12 airports. Projects will reconfigure taxiways that may

confuse, install new lighting systems and provide more flexibility on the airfield.

"The FAA is serious about ending runway incursions, and we are putting substantial resources behind our efforts," said Associate Administrator for Airports Shannetta Griffin, P.E., at the time of the second funding round. "In some cases, the best way to address safety risks is modifying or reconfiguring existing airfields – these grants directly address those situations."

Ted Stevens Anchorage International Airport is one of the airports to benefit from the latest investment tranche. The Alaskan airport has received \$39.8 million to simplify the airfield layout by removing part of Taxiway Z for geometric improvements and installing a new Taxiway E lighting system for Taxiway E and R to enhance safe airfield operations during low visibility conditions, among other enhancements.

Other initiatives the FAA is working on include holding regular runway safety action team meetings at airports across the US and rolling out Airport Surface Detection Equipment, Model X (ASDE-X) or Airport Surface Surveillance Capability (ASSC) and Taxiway Arrival Prediction (ATAP) surface safety technologies at the nation's busiest commercial

airports. A spokesperson also confirms that the agency is enhancing training with modernised simulators to "help us get new hires through training more efficiently".

They add: "We are exploring runway safety technologies that provide capabilities to improve controller situational awareness and reduce runway incursions" and "are working on arrival alert notices for both the pilot and controller".

The FAA has also proposed an extension to the cockpit voice-recording requirement to help identify incident causes, prevent future incidents, and be more consistent with existing international requirements.

While there is already a strong safety net around runway incursions, it is accepted that the existing global safety system could be tightened to prevent future occurrences.

Former Acting FAA Administrator Billy Nolen remarked in his opening statements at the Aviation Surface Safety Summit in May 2023: "There is no question that aviation is amazingly safe. But vigilance can never take the day off.

"We must ask ourselves difficult and sometimes uncomfortable questions, even when we are confident that the system is sound." **AI**

The conditions of the runway environment put aircraft at an increased risk for ground collisions and runway incursions

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Eight Questions

Lockheed Martin has produced some of the world's most innovative and dynamic military aircraft, creating a mystique about what occurs behind the scenes of the OEM. President of Lockheed Martin Aeronautics **Greg Ulmer**, offers insight

Question 1: *Over the decades, Lockheed Martin has achieved a near-mythic status in its ability to design, develop and produce aircraft at the cutting edge of aerospace development. How have you sought to maintain this reputation?*

What we do wouldn't be possible without the people who come to work, ready to give their all in support of our national defence.

We are fortunate in employing many of the industry's best and brightest, and their spirit of innovation inspires me every day. When you think of Skunk Works, for example, being on the leading edge has always been part of the culture. Our people are inherently attracted to innovative challenges that provide a capability to enable superior capabilities and deterrence.

Additionally, across our business we are transforming with urgency to deliver the speed, agility and insights our customers need to stay ahead of rapidly evolving threats. We call this

1LMX, our mission-driven business and digital transformation programme, which helps us transform end-to-end business processes and systems. We're also creating a model-based enterprise with a fully integrated digital thread throughout the design, build and sustainment product lifecycle. We will accelerate 21st Century Security capabilities through innovations and partnerships to support our customers' national security missions.

For example, our Skunk Works Virtual Prototyping team has been perfecting digital transformation methods for nearly four decades, including the transition from analogue drawings to 2D CAD, 3D solid modelling, parametric modelling, digital mock-ups and twins, augmented/virtual/mixed reality, hardware and software innovation and much more.

Another example of how we're applying cutting-edge technology is artificial intelligence (AI). Lockheed Martin provides AI and machine learning solutions that augment human performance by processing, fusing and analysing tremendous volumes of data to give our customers actionable intelligence and a strategic advantage.

Question 2: *Sixth-generation fighters are expected to work with unmanned platforms, such as the loyal wingman or collaborative combat aircraft (CCA). What are your views on this? Are such requirements making the development*

of sixth-generation fighters overly complicated?

Next-generation systems such as CCA and other attritable systems complement fifth- and sixth-generation aircraft and have great potential to unlock new CONOPs for the military. Lockheed Martin's F-22 and F-35 – the world's only fifth-generation fighters – play a critical role in this evolution by enabling simplified control of CCAs from single-seat cockpits.

Integrating autonomy and AI into these systems will provide a decisive advantage for the US and its allies by enhancing lethality and survivability and easing the cognitive workload for pilots. This will enable them to focus more on mission effects and overall strategy, resulting in unprecedented synergistic efficiency and effectiveness. In summary, the future of combat aviation is promising, with sixth-generation platforms and multi-domain integration across a family of systems, including CCAs, set to deliver unmatched capabilities and a decisive advantage in even the most complex scenarios.

Question 3: *Lockheed Martin pioneered the developmental use of stealth with the SR-71 and later the F-117, taking the technology to war in 1991. With the increased capability of sensors, radars and missile technology, is stealth still relevant for sixth-generation fighters?*

Many assumptions are made around the importance of stealth. The bottom line is that stealth remains extremely relevant across all domains today and into the future. The SR-71 and F-117 represented the early days of stealth, successfully countering the threats of that era. As the threats have evolved, so has stealth technology. The F-22 and F-35 advanced our ability to maintain a first look, first shot advantage against the threat through advances in advanced materials, mission systems and sensor fusion. Fundamentally, stealth is the ability of a system to degrade the capability of another system's ability to detect it. Whether in RF, infrared, visual or audible spectrums, we continue to advance this foundational capability to counter current and future threats and leverage other advanced systems on these vehicles.

While this is an extremely sensitive area, I'll say simply that we continue to advance stealth technology across all domains to enable true next-generation survivability and dominance, which we continue to view as a foundational enabler in the future battlespace.

Question 4: Developing reconnaissance aircraft has been a cornerstone of Lockheed Martin's history, from the U-2 to the incredible



SR-71, but much observation is now handled by drones and satellites. Do you think there will ever be a need for a manned high-performance reconnaissance platform again?

Having a human in the cockpit may not always be necessary for future high-performance reconnaissance missions, but the technology to make that possible must be proven and available in the

required quantities. What must be avoided is the idea that any one solution alone can manage this critical mission. Satellites are hugely capable, but take time to move and have a limited shelf life. The time taken to task, replace and launch is improving, but the idea that we can rely on satellite coverage alone is a risk and, frankly, would create an advantage for adversaries. Uncrewed systems can perform long, dangerous missions. There is a reason the U-2 has long been the combatant commanders' preferred choice for ISR. Access timed to need must be agile. They must be responsive, rapidly replaceable, unpredictable, upgradable and persistent, to ensure the DOD has the ability to make strategic decisions timed to need in a resilient and robust air and space integrated manner.

Question 5: Many defence companies in the West have examined what is happening in Ukraine and how their original perceptions of a modern battlefield in Europe have changed significantly through unmanned air and sea systems. What is Lockheed Martin learning from the conflict?

We continue to support the US government's response to the conflict in Ukraine and our thoughts extend to all those affected. Our top priority is ensuring our customers are prepared to navigate today's increasingly complex security environment. By aligning closely with their mission needs, we're innovating with urgency to deliver the most advanced 21st Century security solutions.

We recently saw Ukraine join the worldwide network of F-16 Fighting Falcon operators. With more than 3,100 F-16s operating today in 27 countries, the F-16 remains a benchmark fighter and a key asset in strengthening defence missions for allies, partners and coalitions worldwide. At the same time, we have



been monitoring the evolution of the US Department of Defense's Replicator initiative and analysing its requirements with a strategic, big-picture perspective on achieving air superiority. The modern battlespace demands the right mix of highly capable platforms and attritables working together across domains to achieve mission success. We are working with our customers to determine where we can add from a deterrence and combat perspective.

Question 6: You have been the lead across multiple projects at Lockheed Martin, from the C-130J and U-2 to the F-35. What has given you the most satisfaction as an engineer?

Throughout my career, regardless of the role, I am most proud to work alongside dedicated individuals to strengthen our nation's defence and security worldwide. The products, services and technologies we deliver to our global customers must be reliable, capable and dependable, providing deterrence and the capabilities required to dominate and win. I am incredibly proud of each product and service we develop, produce, and sustain, whether it's a C-130J, U-2, F-35, F-16, F-22, C-5, P-3 or a Skunk Works programme. But it's the people I come back to. I am honoured to work for the Lockheed Martin team. These talented individuals provide our military and allies with the incredibly robust and resilient products and tools they need to preserve our freedoms.

Question 7: Given the 'history and mystery' of Skunk Works and the production line and the exceptional calibre of the employees there, what makes this part of Lockheed Martin different or unique from other manufacturers?

I spent a portion of my career at Skunk Works and can confirm there is an energy and ethos there like nowhere else I have worked – a feeling like anything is possible. When Clarence L 'Kelly' Johnson founded Skunk Works more than 80 years ago, he focused on solving urgent national needs. He developed a



set of 14 rules and practices to guide how work would be accomplished, and those rules continue to be our roadmap. We keep our teams small, empower them and remove bureaucracy as much as possible to allow us to move quickly. Our tolerance for risk is higher than most because we genuinely appreciate that the lessons you learn are key to success. We spend much time understanding the threat environment to anticipate what is coming and align our work to address those future needs. Most importantly, we work in lockstep with our customers to advance what is possible.

Question 8: On a personal level, how do you spend your free time? Any hobbies that you enjoy?

I have a pioneering spirit and I'm committed to serving others. I also enjoy spending time outdoors whenever I can. These passions lead me to focus on family, community and fishing. In addition, I value continual learning, which inspires me to think differently. Currently, I am reading several books simultaneously: *The Demon of Unrest: A Saga of Hubris, Heartbreak, and Heroism at the Dawn of the Civil War* by Eric Larson, *Smart Brevity: The Power of Saying More with Less* by Jim Vandehei, Mike Allen and Roy Schwartz, and *Hidden Potential* by Adam Grant. **AI**

CLOCKWISE FROM ABOVE:

With increasing global threat environments, Lockheed Martin is exploring ways a piloted aircraft can partner with a team of autonomous systems to offer greater mission flexibility at a low cost: Distributed Teaming

All images via Lockheed Martin

The SR-71A Blackbirds provided the United States detailed, mission-critical reconnaissance for more than two decades. The Blackbird was and remains the world's fastest and highest flying manned aircraft...

The F-117A Nighthawk was developed in response to the urgent national need for a jet fighter that could operate completely undetected by the enemy. In true Skunks Works fashion, it was developed rapidly and in complete secrecy

In the 1970s, DARPA oversaw the development of HAVE BLUE, the first practical combat stealth aircraft, which made its first test flight in 1977. This led to the procurement by the USAF of the F-117A stealth fighter

Lockheed Martin's upgrades and enhancements to the F-22A Raptor fleet are meant, to address concerns about the F-22's competitiveness against China's J-20 fifth-generation fighter



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Europe is seeking its own sixth-generation fighter programme with two platforms in the running; the Anglo-Italian-Japanese GCAP and the Franco-German-Spanish FCAS/SCAF Airbus



In March 2019, Harbour Air announced plans to convert an aircraft to run on electric power, since then much of its entire fleet has converted, including the classic DHC-2 Beavers Harbour Air

Next Month

Defining air dominance

Much focus has been on the US NGAD sixth-generation fighter programme and the Anglo-Italian-Japanese GCAP programme. However, other less familiar programmes are underway globally, most notably in Europe, where the Franco-German-Spanish FCAS/SCAF system of systems is in development

Electric Beaver What is the latest from Harbour Air in Vancouver on their ambitious project to electrify the classic de Havilland seaplane?

Noemi seaplane Norway's Elfly Aviation has plans to introduce a new electric seaplane for commuter, cargo, and tourism applications. Mark Broadbent examines the proposal

Powering towards net zero

Until new propulsion technologies are available the only way aviation can reach net zero emissions is with SAF



The nine-seat Noemi will have a 200km range, a 200km/h cruising speed, and will be far quieter than current seaplanes Elfly



Emirates have flown a Boeing 777 with one engine powered by 100% SAF produced by Neste Emirates



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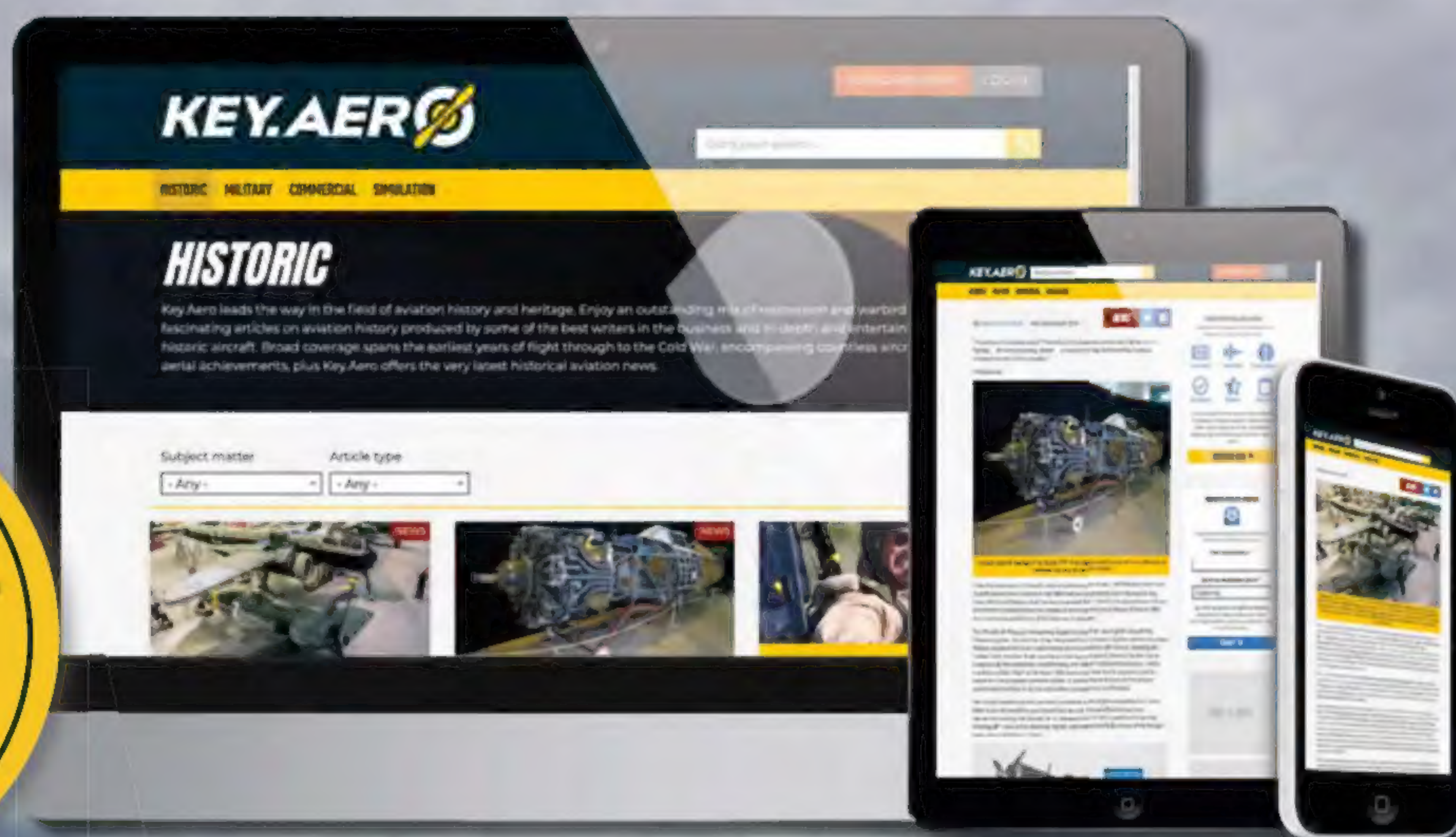
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